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THROUGH THE EYES OF THE EDITOR

M. M. House has issued a challenge to the prosthetic societies and academies as well as to the entire dental profession. He points out the heritage of the profession which was left to it by the rugged individualists of the past who had vision. Because of the work of these men, dentistry of the future can be built on a solid foundation. Certainly the work done by these leaders should be preserved. The means by which it is done will require considerable study, but it must be done for the welfare of dentistry of the future.

Irving R. Hardy has furnished information about the American Board of Prosthodontics for those who may be interested. It is interesting to note that this Board places its emphasis on skill, knowledge, and ability rather than upon the recognition of a limited practice. This principle should make its certificate truly meaningful to the public and the profession.

Vincent R. Trapozzano and John B. Lazzari have attacked the problem of chewing efficiency of the various occlusal forms of teeth in a different manner than has been done before. They have eliminated the variables due to differing denture bases, by making experimental bases. Teeth with various types of occlusal surfaces were attached to these bases. The method seems superior to those previously reported, but it is expensive and this necessarily limits the number of patients upon whom tests may be made. The limited number of tests made indicate that this should be considered a pilot study.

David W. McLean, in discussing the paper by Trapozzano and Lazzari, points out the delay in this phase of research which was due to a lack of adequate space in dental journals in years past. The fact that McLean's work was unpublished has caused researchers to depend upon their memory and hearsay. He suggested that more tests, and tests with other tooth forms, are necessary. This should be done by many researchers before the true answer can be obtained.

Saul C. Robinson has devised an instrument for equalizing the pressure exerted on the supporting tissues by the denture bases while jaw registrations are being made. It is an ingenious hydraulic device with four plungers which contact a plate on the upper base. He claims that the four points of contact produce better equalization of pressure than a central bearing point. We wonder if four points of contact are easier to locate than one. His plea for stabilized baseplates is certainly valid because too many jaw relation records are incorrect solely because the baseplates do not seat at the same position in the mouth as on the cast.

The distinction he makes between centric relation and centric occlusion is most important. Centric relation specifies a relation of one jaw to the other, while centric occlusion specifies a relation of one arch of

teeth with the other. It is imperative that the two exist simultaneously in the mouth. The author is to be commended for making this so clear.

Henry C. Parker has described his technique for making complete dentures and has reviewed some of the fundamental considerations involved in the technique. Some of the procedures he describes do not seem to carry out the fundamentals he has discussed. However, he does have an orderly sequence and an objective which is good.

E. Byron Kelly classifies acrylic denture base materials as "cold" and "hot" according to their method of cure. This simple distinction may tend to clarify the designation of materials that are cured by the catalystic action of materials contained in them as opposed to those cured by externally applied heat. He describes the curing of acrylics as one of cementation by the polymerization of the monomer. Perhaps further study will determine if this is correct.

The discussion of strains and of the experiments to observe them is effective from a practical standpoint even though it may be open to some criticism from the purely scientific approach.

The difference in the sequence of curing of cold- and hot-cured acrylics seems to explain the apparently better fit of cold-cured dentures. Dr. Kelly's plea that the procedures should be carried out correctly and with care is well taken. Too many new materials get bad reputations because they are not properly handled. His hope for standards or specifications for cold materials is certainly worth some consideration. Not enough is known about these materials, and their behavior after processing, to be sure of their value in prosthodontics, but they do show promise. They are clearly demonstrated to be nearly strain free, and they apparently show less dimensional change than hot materials. Their softness and the question of continuing polymerization seem to be the major obstacles to their complete acceptance. They must still be considered as being in the experimental stage of development.

Frank H. Nealon has written about the newest material and method for filling cavities in teeth, and has described some tests of its accuracy. The reasoning back of the technique for making acrylic restorations by the nonpressure procedure seems sound. If the method is to be successful, it is obvious that the technique must be carried out very carefully. Any procedure that is relatively easy to carry out is subject to possible careless technique. The liberties that are taken with amalgam filling procedures cause failures in the restorations. This method can succeed or fail according to the care that is used.

Gerald D. Stibbs takes a philosophic viewpoint as he discusses restorative dentistry. From it he makes a realistic evaluation of dentistry. He points out that the patient's welfare should come ahead of the fee in diagnosis and treatment planning. This is very important if we are to deserve the status of a profession. Most of us work alone (even more than physicians) and thus are own critics. If we fail to be critical of our own work, it can only deteriorate.

He states that research is fine and necessary but that dentists must still practice preventive dentistry by proper restorative dentistry. Until such time as research has eliminated dental disease and until the present generations have passed on, dentists must have the skill and proficiency (which the public should demand) to make adequate restorations. This must be done even if it requires some *work* on the part of the dentists. The easy way is not necessarily the best way. The best way may be difficult and require hard work, but the public is willing to pay to have the restorations made properly.

Edwin S. Smyd has applied dental engineering to fixed bridge fabrication. In this application, he has analyzed the factors that retain abutments. The strength and efficiency of dental cements are compared to structural cements. He has discussed the way in which cements act to hold the casting in place and the factors that cause their failure. He has emphasized the importance of rigidity in the bridge, resistance form in cavity preparation, minimum taper, and other factors in the successful fixed bridge prosthesis. His analyses seem to be sound and fundamental.

Frank C. Starr has made a realistic and practical comparison between porcelain and

acrylic for use in fixed prosthesis. The technique he describes is simple, orderly, and effective.

Thomas E. Moore has discussed the various means to compensate for the shrinkage of gold in small castings. He found variations in the amount of shrinkage of various kinds of gold. He found hygroscopic expansion to produce the most consistent results and that this setting expansion is effective for compensation for the shrinkage of gold alloys. It is his opinion that a combined expansion of 1.50 per cent is necessary to compensate for casting shrinkage. This differs from the opinion of some other investigators. These results should be subjected to further tests.

Bruce C. Martin and John C. Trabue have discussed some of the problems of surgical treatment of children with cleft palates. It is important that prosthodontists understand these problems for such children are ultimately prosthetic patients. It is significant that these plastic surgeons urge cooperation between the surgeon, prosthodontist, orthodontist, and speech therapist in the diagnosis and treatment of these unfortunate children. The team approach seems to be gaining favor throughout the country.

S. G. Applegate and Lawrence Cotman give an interesting description of a case of congenital ectodermal dysplasia and its prosthetic treatment. The patient is a brother of the one reported by Applegate and Savara (**2**:418, 1952). The variations in the problem and treatment are emphasized, and the psychologic advantages to patients with this endocrine deficiency are appraised. The psychologic effect is noticeable, not only upon the patient, but on the dentist as well.

—Carl O. Boucher

PRESIDENT'S ADDRESS

The Academy of Denture Prosthetics

Raymond J. Nagle, D.M.D.

Boston, Mass.

MR. CHAIRMAN, members of the Academy of Denture Prosthetics and honored guests:

It is with solemn appreciation that I address you today as president of this Academy, because I have come to realize more with each year of my membership what a privilege it is to be a member of such a group.

In 1771 John Hunter, an English scientist, published "Natural History of the Human Teeth"; later he published "Practical Treatise on the Diseases of the Teeth." It has been said that these works and Hunter's observations in dental science marked the beginning of a new era in dentistry and that because of his pioneering he paved the way for others who over the years have brought dentistry to the high position it now holds in the field of medical specialties. It was the same type of scientific and pioneering men who, in 1918, founded the Academy of Denture Prosthetics. It was not an academy then, but a group interested in prosthetic dentistry, lecturing, and writing to inform those interested in this major field of dentistry. As we review the literature we find it highlighted with the names of those who founded this prosthetic group, which today has become one of the greatest fountains for the dissemination of knowledge in the field of denture prosthetics. The dental profession looks to this Academy for new advances in techniques and theories. Because of this enviable position we should consider where best a contribution can be made. For your consideration I present three recommendations:

1. An active interest in dental education and its relation to prosthetic dentistry must be taken. In late years new forces have exerted themselves in dentistry and dental education to a major movement toward the goal that the biologic has been suppressed in dental teaching and practice to the overemphasis of the mechanical arts. When this movement started, I am not certain, but possibly the Geis report (resulting from the study in 1920) was one of the motivating forces. To quote from that report briefly, "Development of the art of dentistry into the equivalent of an oral specialty of the practice of medicine would require a new and more comprehensive definition of dentistry, a corresponding extension of the scope of dental health service, and commensurate improvement in dental education. Expanded as it should be in biologic scope, and strengthened in all its health service aspects. . . ." There has been great im-

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provement toward the biologic in dental teaching, a change in which I am most heartily in favor, and, as you know, have been most active for the change. During the past decade, however, this momentum has been so great that the teaching of prosthetic dentistry has been in considerable danger of gradual but certain reduction in the student schedule. This reduction when it has occurred has by my observation been motivated by those lacking in true dental understanding or sympathy. I would recommend to you that the Academy of Denture Prosthetics, because of its position, whenever possible and through the Council on Dental Education resist the reduction of time allotted to the teaching of prosthetic science. As a teacher, and more recently as a dental examiner, I can see in the graduates of the past five years young men with very apparent lesser training in this important field.

2. The object of the Academy as stated in the constitution in part is ". . . to encourage study and investigation in the various phases of denture prosthetics and related subjects." Encouragement and stimulation by leaders in any field does much toward progress. With this in mind and also conscious of the fact that prosthetic dentistry has become a target for curricula reorganization, I recommend that the incoming president appoint a committee to study the feasibility and value to dental education of a grant in the sum of five hundred dollars each year to be awarded to a graduate or postgraduate student enrolled in an accredited course of study specifically "For original research in the field of denture prosthetics."

3. In the foreseeable future, it is quite possible that the constitutional limitation as set down in Article IV (which in effect states that the membership shall be limited to fifty active Fellows) may close the door for membership to very worth-while and desirable candidates. The increased interest in denture prosthetics as a specialty since the founding of the American Board of Prosthodontics has shown many outstanding men in this field, some of these are interested in the Academy of Denture Prosthetics and are desirous of becoming members.

It is *not* my feeling that this Academy should have a large membership, because in my opinion its position of leadership is due in a large measure to the fact that it is small in number. However, we must look to the future, recognize possibilities, and be prepared. Therefore, I recommend that the Executive Council consider the advisability of amending our constitution to this effect: "Membership not to exceed 60 in number."

There is nothing in my professional career that has impressed me as much as has the honor and privilege of being your president, a position I am now leaving. But I am doing so with a feeling of accomplishment and of pride that my name will appear in the list of past presidents, many of whom were responsible through their writings and teachings in my development in the field of prosthetic dentistry.

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A CHALLENGE

M. M. House, D.D.S.

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"ONE OF the best methods of rendering study agreeable is to live with able men, and to suffer all those pangs of inferiority which the want of knowledge always inflicts."

The foregoing quotation from the pen of that great English essayist and clergyman, Sydney Smith, must have been somewhere lurking in the minds of those men who over thirty-four years ago brought forth the idea of a prosthetic society, the sole purpose of which was the stimulation of a desire for advancement in knowledge and service.

So intent were the founders of this organization that it should be, above all other things, a sincere group of men seeking for only the truth and a means of disseminating that truth that they wisely defined their desires and aims in the second paragraph of the Constitution which reads as follows:

"The object of the Academy [of Denture Prosthetics] shall be to promote the science and art of denture prosthetics as a specialty of Dentistry; to provide for the dissemination of knowledge concerning this specialty throughout the Dental Profession; and to encourage study and investigation of its various phases and related subjects."

When these facts are considered, it seems evident that three factors were paramount in the conception and birth of this Academy. They were: (1) investigation, (2) research, and (3) dissemination.

After thirty-four years of existence, let us review our activities and evaluate our accomplishments and see, if possible, wherein we have failed to meet our responsibilities and to what extent we may have tasted of success.

Investigation and research are, in a measure, synonomous, but as a means of better understanding in the estimation of our accomplishments we will distinguish between the two and define *investigation* as a systematic inquiry into the proposed theories, techniques, and materials which have been presented and advocated for the advancement of prosthetic dentistry.

In this field, the Academy seems to have measured up to its requirements and expectations. Every denture technique which has been presented to the profession has undergone the rigid scrutiny of the organization, and an honest attempt has been made to evaluate its worth step by step. It has commended that which is good and rejected with reason that which seemed questionable.

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No theory, technique, or material has ever been officially condemned by the Academy, and only once has the organization ever officially adopted, as basic and fundamental, a theoretical or technical procedure. In every step of investigation the ideal of honesty, impartiality, and sincerity has at all times prevailed.

Research we will define as continued, scientific, and diligent study of certain phenomena relating to denture construction. Here the Academy has served as an open forum where all men with abilities along research lines have been welcomed.

The geometry of mandibular kinematics, the functional distribution of anatomic forces in mastication, the physics of occlusal relationships in function, and many other similar problems have received wide and varied consideration by men capable and competent of analytical study.

Research is a never-ending seeking after truth, and it is believed that this Academy will forever meet its obligation in this field.

Dissemination means "the sowing or scattering broadcast," and for our use here we will add the words "of knowledge and information."

At times in the past, the Academy has been criticised by some members of the profession at large because of its failure to adopt and recommend certain denture techniques, basic principles, and theoretical ideas, most of which have been controversial in nature. This is not and never has been the intended function of the Academy. All theories, principles, techniques, and materials have at all times been carefully studied by the Academy, and an honest attempt has been made to clarify to the greatest degree possible every controversial matter. This has been done to the extent where intelligent men, knowing the facts, may be competent to choose for themselves that which might seem most practical in their hands.

We believe that the Academy has met and is meeting its responsibility in this field as set up and outlined by those who charted the course for the Academy to follow.

The field of investigation and research is a never-ending one and, this being the case, it logically follows that the field of disseminating the knowledge gained is not only never ending, but a constantly increasing one. Prosthetic dentistry has expanded in many ways during the past few years and with this expansion has come a collateral expansion of the obligations and responsibilities of the Academy. These obligations and responsibilities have been rendered much more potent by the insidious and vicious attacks which have been made upon the subject of prosthetic dentistry in the dental schools throughout the country.

The present trend in our colleges is more and more toward specialization in both medicine and dentistry, and specialization in the practice of both professions is almost universal at present.

A shortage of experienced teachers in our dental colleges and the limited facilities for supplying the number of dentists necessary to properly care for the oral conditions of our present population is a definite problem to be considered.

Our local, state, and national dental meetings are of much interest and inspiration as are also our many national specialty meetings.

Many of our dental schools are giving graduate and postgraduate courses in specialized subjects that are helpful and beneficial to graduate dentists who are preparing to specialize in their practice. With all of these educational facilities plus the great libraries, and the volumes of our dental literature, it would seem that our socioeconomic and educational facilities are most complete.

Many in our profession who have traveled a great deal, and have visited many of our dental schools and departments of research and museums, both medical and dental, and many that have privately-owned museums, will be able to visualize and appreciate how valuable a great centralized dental educational museum would be to this age of specialization. Dentists who have traveled broadly have visited many of these exhibits. But they have seen relatively few of them that could have been seen and studied in a great centralized museum, where much more detailed study would be made possible by carefully prepared legends and descriptions.

Many of the wonderful collections in our colleges that were of inestimable value to dental education are now stored or destroyed. These collections and specialized preparations have been the results of the vision and work of individuals who have found their work. This means that fortunate are people who have found a work for which they have native talent.

An ideal setup for a dental educational museum would be as follows:

1. It should be established in a centralized location in the United States of America.
2. It should be placed at a university location where all educational facilities are present on one campus.
3. It should be placed in a location where summer vacations would be ideal.
4. It should have a department for each specialty of dentistry. The exhibits of each specialty would be placed in glass cases with legends, or a correctly prepared description, for each case or step in the sequence.
5. It should have a department for exhibits of research on things pertaining to dentistry.
6. It should have a department for all kinds of anatomic specimens, et cetera.
7. There should be an exhibit department for the instruments, engines, chairs, cuspidors, and appliances in the early development in dentistry.
8. There should be a "hall of fame," with photographs of the great contributors to dental science and education and a brief history of their work and developments.
9. Each dental school should be represented with duplicate exhibits of their own exhibits.
10. There should be a department for exhibits by the dental manufacturers and dental laboratories where they could display their goods. These exhibitors should pay a reasonable advertising fee to help defray the expense of the museum.
11. Men selected to teach in our dental colleges should be endowed for a year or two years of preparation at the institution, provided they would sign an agreement to teach for a given period of time in the institution that selects them. It would permit teachers and also practitioners in all specialized branches

of dental practice to have a broadened knowledge and conception of dental service to humanity.

12. There should be a six-weeks' seminar held each summer at the university which would house the museum. During this time, a select group of the most outstanding teachers in the various specialties of dentistry would give courses so graduate dentists could take advanced work in line with their special interest. These teachers would work with their individual groups four days a week. The fifth day would be for general assembly, at which time the teachers giving courses would present their work to all who were taking the courses. This would be of benefit to both general practitioners and specialists. Saturdays and Sundays would be for rest, vacations, or opportunity to study in the museum.

Contributions by American Dental Association members, endowments by philanthropists and by specialty organizations, tuitions for courses, and rental of exhibit space by advertisers, could make such an institution a reality.

1601 Scenic Dr.
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THE AMERICAN BOARD OF PROSTHODONTICS

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THE American Board of Prosthodontics is an institution which was originally set up at Miami, Fla., in October, 1946, pursuant to authorization by the American Dental Association. The original Board of nine members was representative of the American Denture Society, the Academy of Denture Prosthetics, and the Pacific Coast Society of Prosthodontists, three organized groups whose efforts over a long period of years have been devoted to the accumulation and dissemination of knowledge in the field of removable dentures.

The Board was incorporated Feb. 21, 1947, in the state of Illinois, as a non-profit organization for the protection of the public ". . .from representations of unqualified persons that they are qualified specialists in prosthodontics. . ." and to ". . .issue certificates of qualification to such persons as are duly qualified so that dentists or physicians may refer difficult or unusual cases with confidence that the patient will receive necessary expert attention."

The Board's purpose in the profession is to be a stimulating and guiding factor in the promotion of higher standards and more effective patient service in prosthodontics.

When the Board was originally set up, cognizance was taken of the fact that there were, in active practice, a considerable number of men whose activities in the field of prosthodontics were so outstanding that charter certification must, in all fairness, be granted such persons without formal examination by the Board. After careful screening of all who considered themselves entitled to charter certification, sixty-nine such certificates were issued. The Board regrets that some very expert prosthodontists who could have qualified for charter certification did not apply, but by far the larger proportion did so, and the Board appreciates the support and prestige they supplied during the formative stage of the Board's existence.

In 1949, the first examinations for certification were held in Chicago at the University of Illinois College of Dentistry, at which time fourteen men qualified for certification. Further examinations have been held; in 1950 at Marquette University School of Dentistry, 1951 at the College of Dentistry, Ohio State University, and again in 1952 at Marquette, with a total of forty-five men qualifying, so the roster now totals 125.

Since the examinations given by the Board are of five or six days' duration, and thoroughly clinical as well as theoretical, it has seemed practical to hold examinations only once a year. The entire Board acts as an examining com-

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mittee, and thirty canditates seem to be the maximum group who can be given examinations at any one time.

Any qualified dentist who graduated from an accredited dental school *before* Jan. 1, 1947, and who has had ten years or more of practice, with special training in prosthodontics, may apply for examination, subject to the rules of the Board. Any qualified dentist who graduated *after* Jan. 1, 1947, may apply for examination, provided he shows evidence of study after graduation which is acceptable to the Board. More detailed information will gladly be supplied to any interested practitioner upon request to the Secretary of the Board.

Starting with no criteria for conducting examinations on a "specialist" level, the Board has continually re-evaluated its procedures on the grounds of experience and now feels that it is making definite progress in its original objectives of stimulation to the profession and protection to the public.

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AN EXPERIMENTAL STUDY OF THE TESTING OF OCCLUSAL PATTERNS ON THE SAME DENTURE BASES

VINCENT R. TRAPOZZANO, D.D.S., AND JOHN B. LAZZARI, D.D.S.*

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PROSTHODONTIA constitutes one of the most interesting and challenging phases of our profession; yet, it is a phase of our work which lends itself to violent disagreement and confusion, the effect of which is to produce bewilderment in the profession. Despite the labors of many individuals to seek fundamental knowledge, and exhaustive investigation in the many ramifications of prosthodontia, the result of our accomplishments still leaves us far from an adequate solution to its many problems.

For some reason, prosthodontia has the faculty of producing violent reactions in either the sponsor or followers of a certain technique or in the interpretation of a so-called basic concept. To illustrate, one will find extreme partisan reaction as to the type of impression to make and what material to use, and under what circumstances we should use this or that technique or material. Again, in occlusion we have the group which believes in the use of this or that articulator frame; those who use no articulator frame; those who set teeth on a flat plane or a curved plane or a reverse plane (Avery), or combinations thereof; those who use an anatomic or "cusp" tooth, or a nonanatomic tooth with the many and myriad variations of each general type. There is even disagreement as to what constitutes the masticatory cycle. Perhaps this is a normal situation which confronts us, or it may depend upon our range of vision when we make our evaluations. Our range of vision will color our thoughts, concepts, and our practice.

It is certain that no one procedure or technique can be applicable for use on all of our patients. Variations are a necessity if we are to render the highest possible type of service for each individual patient. It is possible that these necessary variations are among the causes for confusion.

One of our major difficulties in evaluating the truth or worth of a so-called basic concept or technique is the inherent difficulty of performing controlled experiments in prosthodontia. But wherever possible, this must be done if we are to evaluate without bias or prejudice which, though sincere, may nevertheless be misguiding. As it is today, many of our concepts and techniques are based upon evaluation placed upon them by individuals who too frequently are in reality stating opinions and not facts. Who is to say what is correct and what is not?

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The present experiment represents an attempt to set up a basis for a controlled study of occlusion. It is believed that by this means it is possible to study the various tooth patterns, concepts of occlusal planes, and to make comparisons in the use of fully adaptable, semiadaptable, and hinge articulating frames, and so forth.

To make this study, it was necessary that all factors except the one to be tested were made constant. Thus, one of the most important steps in the present experiment was to produce a base which could be made to serve as a common base for all occlusal changes. In this manner, the type of impression made, its extension, fullness, adaptation, retention, and so forth, would remain constant throughout the experiment. By having a single base, any changes which might be made in the base would produce a common factor of change throughout the experiment. Thus, if the change produced a harmful or undesirable result in the testing of one type of occlusion, the error would be constant for all other types tested. Construction of the base had to be made so that the entire artificial dentition could be placed in position or removed from the base with ease and accuracy.

The motivation for this study was received at the Houston meeting of the Academy of Denture Prosthesis in 1941, where McLean[1] presented his work on chewing efficiency tests. The work was as follows:

"The master casts were made from the original impressions, and mounted, with scored bases, on a Terrell articulator which was then adjusted by the House chew-in technique. The 45 degree cusp dentures were set up, tried in, and cured by a long, slow cure which would not disintegrate the casts. The case was returned to the articulator, to the [mounting] bases formed by the scored bases of the casts, for occlusal post-cure correction.

"Formation of subsequent casts was as follows: The upper 45 degree cusp denture was lightly lubricated and a new cast was poured into it. The upper cast was then mounted on the formed base on the upper bow of the articulator, in intercuspation with the lower denture, in centric relation.

"The lower denture and its cast were removed from the articulator. The lower cast was scored across its undersurface at the anterior end of the posterior outward flare just anterior to the heel and the piece was broken out. The rest of the cast could then be pried out of the denture. A new lower cast was poured in the lightly lubricated lower denture and mounted on the articulator base in centric intercuspation with the upper denture.

"This gave each new pair of casts the same orientation on the articulator as the master casts, and all eleven pairs of dentures could be mounted on the master casts in turn and put through the same mandibular movements on the articulator."

More recently, chewing tests were made by Payne[2] who constructed two sets of dentures for the same patient on duplicate casts but with different occlusal patterns. The experimental objective was, of course, to test tooth forms on identical bases. However, it is felt that both of these experimental procedures were not sufficiently accurate on two counts: (1) Pouring of the casts. Unless the water-powder ratio of the stone is kept constant, dimensional changes will occur. The presence or absence of air bubbles in the mix will also determine the density of the

cast and may become an important factor in the curing process. (2) Adjustment of denture bases. This is probably the most serious objection to the use of duplicated denture bases. If it is found that a change must be made in the denture base (for example, the reduction of a slightly overextended periphery, peripheral width, and so forth), it would be impossible to correct the balance of the duplicate dentures exactly the same amount. If our experiment is to be scientifically acceptable, these possibilities of error must be eliminated.

Thompson,[3] in his very fine study, used a common base with a slotted arrangement for the posterior teeth so that the posterior teeth could be interchanged at will. While this adequately solved the problem of interchangeability of the posterior teeth on a common base, it had one serious drawback; it left the relationship of the anterior teeth fixed. Thus, whatever incisal guide angle was determined upon, it remained unchangeable throughout the experiment. This, it is felt, imposes a serious limitation on the scope of the studies which can be made.

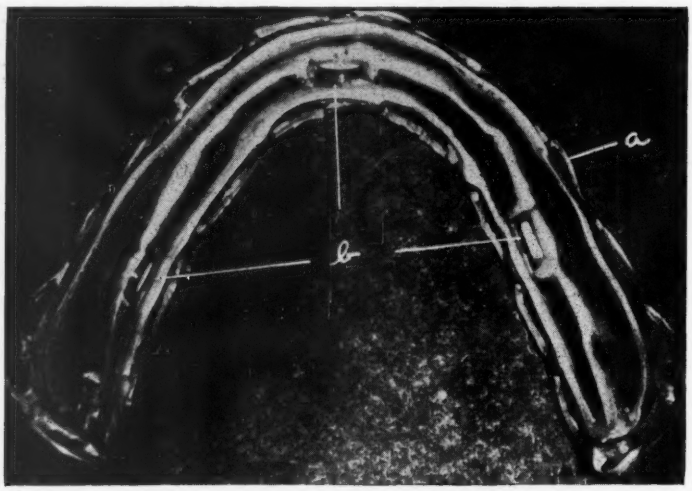

Fig. 1.—Lower test cast gold base. *a*, Retention loops for attaching the plastic part of the base. *b*, Rectangular posts for the attachment of the interchangeable occlusal patterns.

A fixed incisal guide angle will immediately set this one controlling end factor of occlusion and, as a consequence, limit the degree of change which can be introduced in the setting up of posterior teeth. For example, if a steep incisal guide angle is deemed necessary during the testing of one type of setup, lack of freedom to change the degree of incisal guide angle will impose this condition on all subsequent setups which may be attempted. Since the angle is fixed permanently, no change can be made. An experimental comparison between cusp and noncusp teeth would be either impossible or seriously handicapped.

CONSTRUCTION OF BASES AND INTERCHANGEABLE DENTITION

Two methods were used to construct bases which would permit rapid and accurate interchange of the occlusal patterns:

Method 1.—After recovery of the casts from the final impressions, the casts were surveyed for tissue undercuts and cast gold bases were constructed (Figs. 1 and 2,*B*). On the lower casting, to insure sufficient coverage and to permit a well-

rounded periphery, the buccal, labial, and lingual extensions were completed in acrylic. Retention loops were thus constructed along the periphery of the gold casting below the finishing line to serve as a means for attachment of the acrylic base material (Fig. 1,*a*). To provide for positive insertion and retention of the occlusal segment, three rectangular posts were formed on the gold base. These posts were placed well to the lingual and situated so as to cause the least amount of interference during the setting up of the teeth (Fig. 1,*b*). Holes were drilled and tapped into these posts to receive Allen screws. Essentially the same procedure was used in making the upper casting. The palate portion was not cast in gold in an attempt to reduce the weight of the denture.

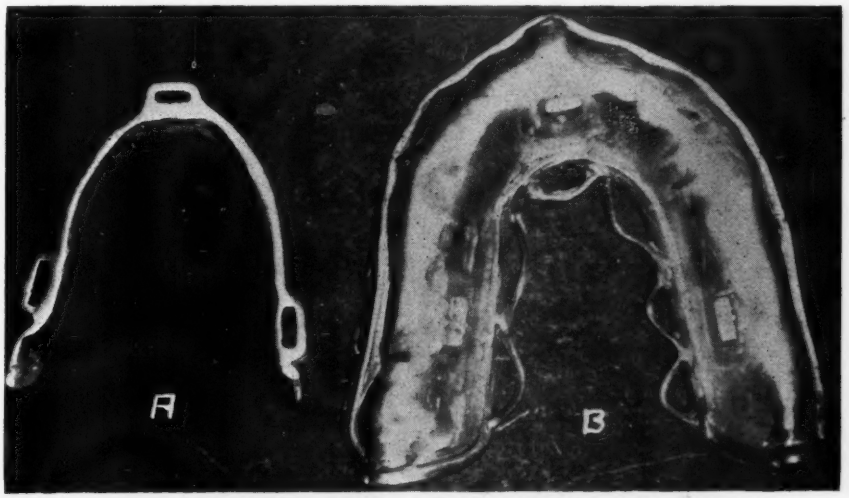

Fig. 2.—*A*, Rigid gold bar to be embedded in an interchangeable acrylic insert. *B*, The upper test cast gold base, with the attachments on which the bar fits.

After numerous trials, it was found that the acrylic insert which carried the teeth could not be made to seat accurately on the gold base after the cured acrylic insert had once been removed. The inherent inaccuracy of our acrylic denture base material became quite apparent. Many methods of curing and many packing techniques were used in an attempt to overcome this dimensional change. Among the methods employed were: the long (six to nine hours) curing time, at 158° F. and at 160° F. and no boiling; three hours at 158° F. and one-half hour of boiling; quick chilling; overnight bench cooling; pressure packing and flask closure; and acrylics made by various manufacturers. All methods produced sufficient change to make reseating inaccurate. It was finally decided to embed a rigid casting in the wax setup and then cure the acrylic. By this method, it was possible to produce acrylic inserts that seated accurately. The metal bar was formed in the shape of a loop with keys to fit onto the posts of the gold casting (Fig. 2). Holes were drilled and tapped into the keys so that the bar could be held rigidly to the post by means of the Allen screws. Vertical dimension, check bite records, face-bow transfer, etc., were made, using the gold castings as bases. The casts were then mounted on a Hanau Model H articulator with split mounting plates attached.

A tentative setup of teeth was made, and a recheck was made of vertical dimension and centric relation. Protrusive records were secured. Lateral condylar inclinations were set on the articulator in accordance with the Hanau formula.

In this first series of experiments, it was decided to test three different types of posterior teeth. They were (1) 20 degree, (2) Hall, and (3) DeVan posterior teeth. Further, it was decided to set up the 20 degree and Hall posterior teeth in accordance with the laws of articulation in order to secure bilateral balance within the limits of the articulator used. The buccolingual and the up-and-down position of the teeth was duplicated as carefully as possible. Mold 29M 20 degree posterior teeth and Mold 30SN Hall posterior teeth were used.

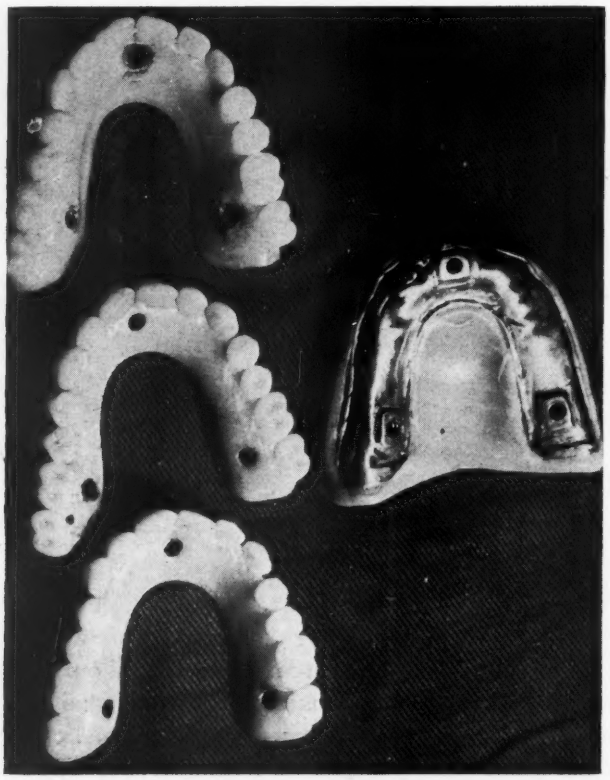

Fig. 3.—*A*, Insert with DeVan teeth. *B*, Insert with Hall teeth. *C*, Insert with 20 degree teeth. *D*, The completed upper test base.

DeVan posterior teeth were set up on a flat plane and, of course, lacked bilateral balance on the articulator. The only mold available was used. It is slightly larger than either the 20 degree or Hall posterior teeth.

Each separate setup was cured and processed, removed from the gold bases, and the next setup made and cured. After the three setups were cured and processed, the peripheral borders of the maxillary and mandibular bases and palatal portion of the maxillary base were cured. The casts were returned to the articulator and reseated in their original mounting by means of the split remounting plates. Each set of the teeth was then placed in position on the gold bases, seated

on the casts, and curing changes corrected by means of selective spot-grinding. Cusp angulation was reduced on both the 20 degree and Hall posterior teeth to harmonize with a flat incisal guide angle. With the DeVan posterior teeth, lingual to insure no interference during the set up of the teeh. The bases were corrected, and the anterior teeth were checked to be sure that there was no interference in either centric or eccentric positions (Figs. 3-5).

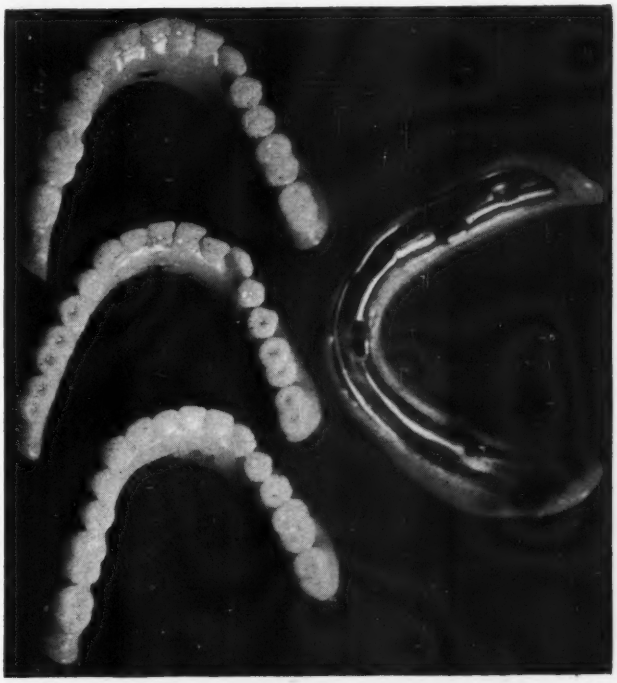

Fig. 4.—*A*, Insert with DeVan teeth. *B*, Insert with Hall teeth. *C*, Insert with 20 degree teeth. *D*, The completed lower test base.

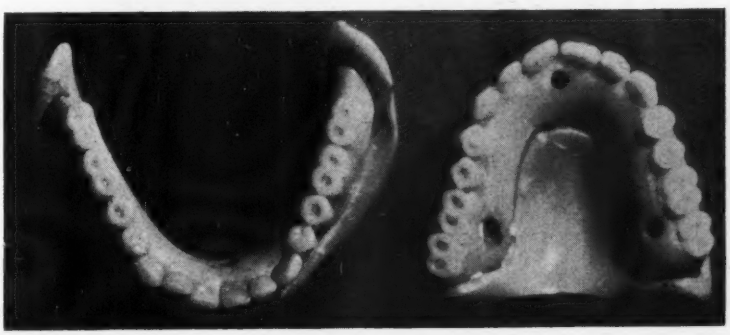

Fig. 5.—The inserts with the Hall teeth in position on the bases, but without the Allen screws.

Method 2.—Duplicate refractory casts were made of the casts which had been recovered from the final impressions. A wax of sufficient thickness to permit casting in aluminum was made (Fig. 6). A raised flange (Fig. 6,*a*) was made on the lingual of both the maxillary and mandibular bases, and placed far enough to the

lingual to insure no interference during the set up of the teeth. The bases were then cast in aluminum. A rigid gold casting was made similar to the one previously described in Method 1. Holes were drilled and tapped in the flange and rigid gold bar to receive Allen screws (Fig. 6,*b*). A slight variation of this procedure is

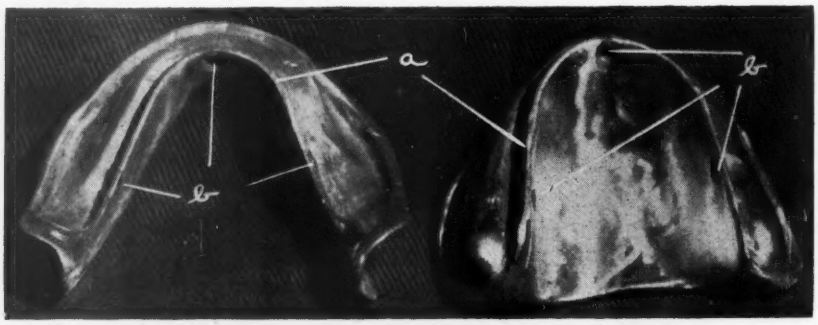

Fig. 6.—Cast aluminum test bases. *a*, The raised flange. *b*, The holes drilled and tapped to receive Allen screws.

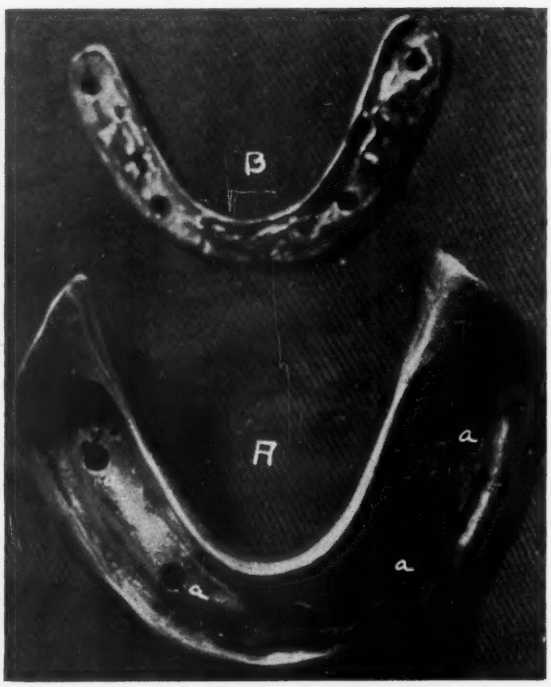

Fig. 7.—*A*, Cast aluminum base with holes *(a)* for Allen screws which attach the insert to the base. *B*, Gold reinforcement for a plastic insert.

shown in Fig. 7,*A*. The holes are drilled and tapped through the bases (*a* in Fig. 7,*A*). Fig. 7,*B* shows the gold casting used to prevent change of the acrylic insert which will carry the teeth. After the aluminum bases and gold reinforcement bars are made, the procedure was essentially the same as that previously described (Figs. 8-11). The gold reinforcement castings are embedded in the acrylic inserts which carried the teeth.

The question arises whether to use experienced or inexperienced denture-wearing patients with whom to conduct the experiments. Both types of patients would present advantages and disadvantages. The inexperienced patient would be free of preconceived notions regarding the wearing of dentures and might, therefore, be able to approach the test with an unbiased opinion. Lack of experience

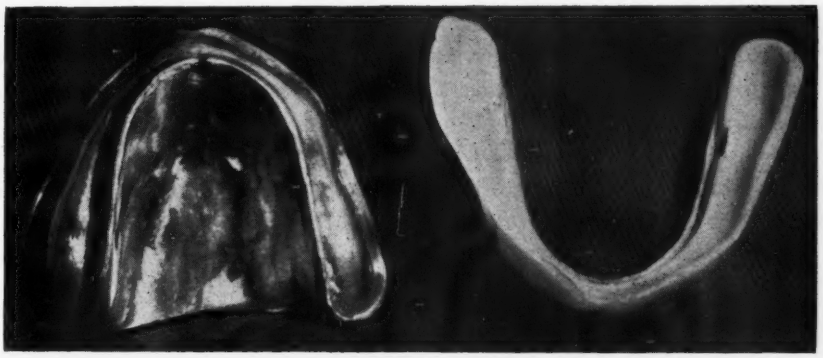

Fig. 8.—The upper aluminum base and the base surface of one of the acrylic inserts which carry the teeth. Note that the gold reinforcement casting is embedded within the acrylic insert.

Fig. 9.—The lower aluminum base and the base surface of an acrylic insert.

Fig. 10.—The inserts with Hall Posterior teeth in position on the aluminum bases, but without the Allen screws.

would, however, be detrimental in that the patient would have to be permitted a varying length of time in order to learn the fundamentals of denture control with lips, cheeks and tongue, and to adjust the mental outlook toward the wearing of dentures. By this time, the patient could no longer be classified as inexperienced. It was therefore decided to conduct this first series of experiments on patients who had been wearing dentures for some years. Selection of patients was made on the basis of intelligence, dependability to follow instructions, and available interridge space. All of the patients used in these experiments live at the Veterans Hospital at Bay Pines, Fla. Because the patients lived at the hospital, they were available at all times.

Forty-eight hour cycles for the wearing of each occlusal tooth pattern were established in order that the patient could better remember the experiences encountered in that length of time. To have increased the number of posterior patterns tested or increased the number of days between changes might have extended the testing beyond the memory range of the patient. The procedure was repeated twice before chewing tests were made.

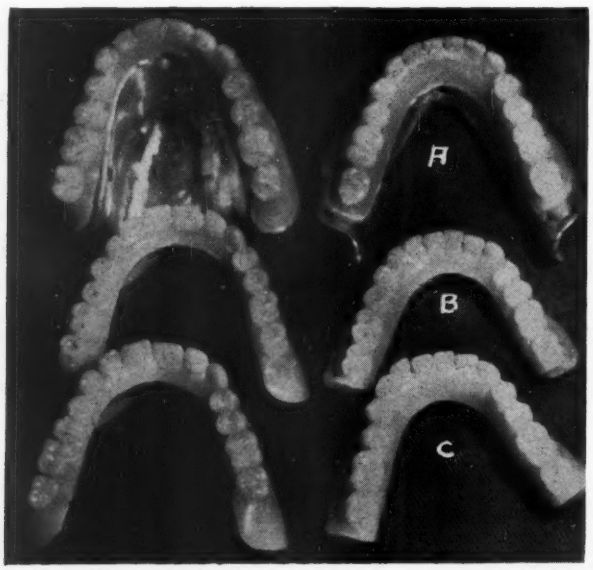

Fig. 11.---The test bases with the three sets of acrylic inserts. *A*, With DeVan posterior teeth. *B*, Inserts with Hall posterior teeth. *C*, Inserts with 20 degree posterior teeth.

CHEWING TESTS

The chewing tests were made with fresh raw carrots and roasted peanuts. Carrots were selected because this vegetable does not readily disintegrate into extremely fine particles during mastication. The carrot does, however, absorb moisture (saliva) during mastication so that comparison of weights before and at the end of the chewing test have no correlation. The difference in weight would not represent the amount of material passing through a test sieve. The weight after mastication would also include the amount of moisture absorbed during mastication. The amount of moisture absorbed would vary depending upon the degree of the patient's salivation, length of time the bolus would remain in the mouth, and

the degree of maceration that the particular patient would produce with any given set of teeth being tested. Because of the factor of coherence, the carrot makes an excellent food for observing particle size and was used for this purpose alone.

The roasted peanut, on the other hand, becomes easily macerated during mastication and as a consequence much of the material passes through a test sieve. The weight of the material passing through a sieve can be quite accurately determined, in the case of the peanut, because the particles remaining in the test sieve can be dried and the moisture absorbed during mastication can be eliminated. Peanuts also offer a fine opportunity for observation of particle size.

A 100-mesh screen was used for a sieve to study remaining particle size and weight changes in the test material after mastication in the tests.

The number of masticatory strokes the patient was permitted was first determined by allowing the patient to make a test chew. The number of strokes which the patient made, up to the time that deglutition started, was counted. In the cases cited, the patients were ready to swallow the bolus at thirty plus strokes. The testing was therefore limited to twenty-five masticatory strokes.

The carrots were cut into approximate ⅜ inch squares. No attempt was made to dictate to the patients the number of squares they were to attempt to chew at one time. Patients have their own idea of the size of food bulk which they feel they can handle during mastication and to interfere with this free selection *could* influence their chewing stroke. One patient did make a false start, that is, he took in a greater amount than he could handle. That bolus of food was discarded and a new start made.

It was suggested to the patients that they chew in any manner which was most comfortable to them, that is, on the right or left side, or both right and left sides at the same time. It was noted that all chewing was done on either the right or left side with little or no change from one side to the other. In other words, if chewing was started on the left side, it was completed on that side. None chewed on both sides *at the same time.*

CASE I M.—*Results of Chewing Tests With Carrots:* About 5.2 grams of carrots were diced into approximately ⅜ inch squares. Twenty-five masticatory strokes were permitted for each mouthful. The particle size resulting from the use of the DeVan and 20 degree posterior teeth seemed to be relatively uniform and equal in size. The particle size resulting from the use of Hall posterior teeth seemed to be more finely ground (Fig. 12).

Results of Chewing Tests With Peanuts: Approximately 5.2 grams of shelled roasted peanuts were used to conduct these tests. As with the carrot, the patient was allowed twenty-five masticatory strokes for each mouthful.

As with the carrot, the particle size resulting from the use of the DeVan and 20 degree posterior teeth seemed to be relatively uniform and equal. Here again, the particle size resulting from the use of the Hall posterior teeth seemed to be more uniformly and finely ground (Fig. 13).

The masticated bolus of peanuts was weighed after screening with the results shown in Table I.

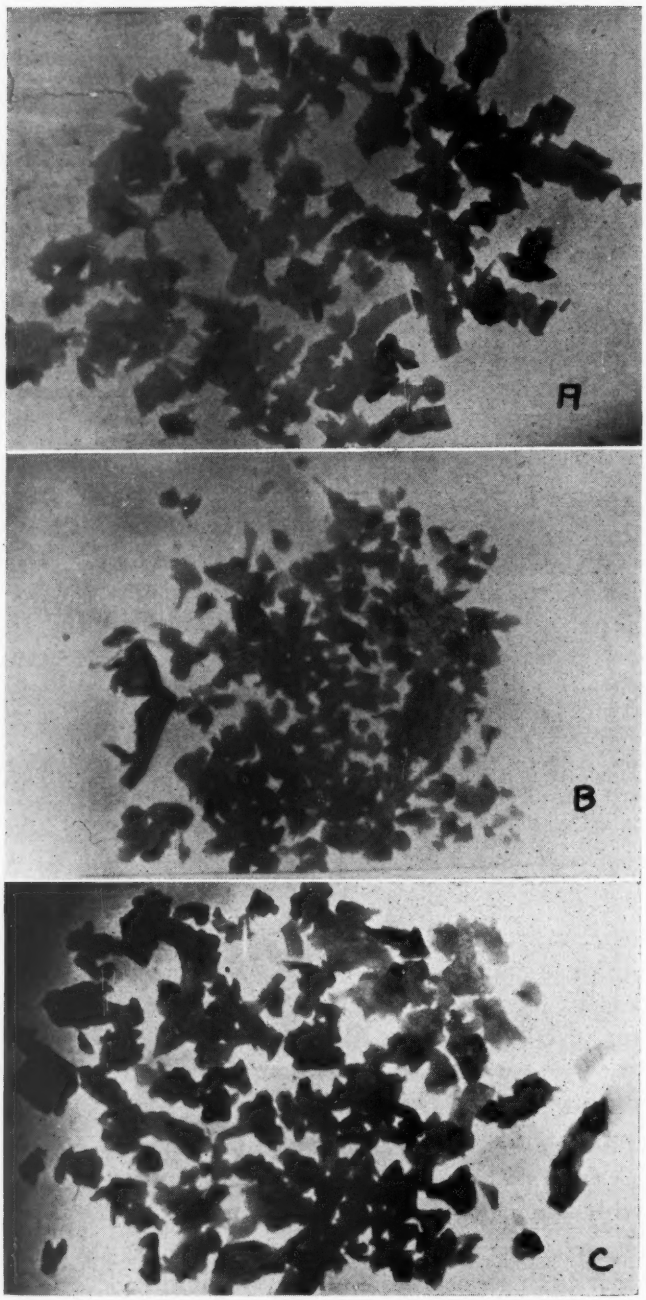

Fig. 12.—The particle sizes of carrots in Case I M after twenty-five masticatory strokes. *A*, with DeVan posterior teeth; *B*, with Hall posterior teeth, and *C*, with 20 degree posterior teeth.

On the basis of the weight of the peanuts passing through the 100-mesh screen, the 20 degree posterior teeth were 18.8 per cent more efficient than the DeVan posterior teeth and 32.5 per cent more efficient than the Hall posterior teeth (Fig. 14).

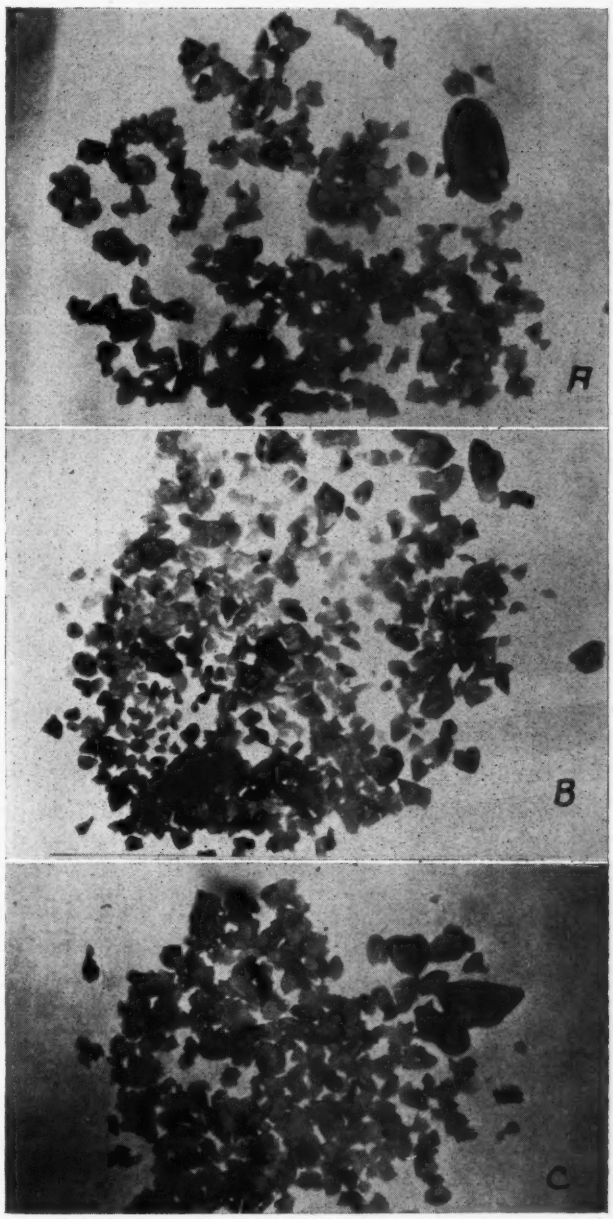

Fig. 13.—The particle sizes of peanuts remaining in the 100-mesh screen in Case I M after twenty-five masticatory strokes. *A*, With DeVan posterior teeth; *B*, with Hall posterior teeth, and *C*, with 20 degree posterior teeth.

TABLE I. CASE I M

TOOTH TYPE	WGT. PEANUTS CHEWED (Gm.)	WGT. PEANUTS RECOVERED (Gm.)	WGT. PEANUTS PASSING THROUGH 100-MESH SCREEN (Gm.)	% PASSING THROUGH SCREEN
DeVan	5.2	2.4	2.8	53.7
Hall	5.2	3.1	2.1	40.0
20 degree	5.2	1.4	3.8	72.5

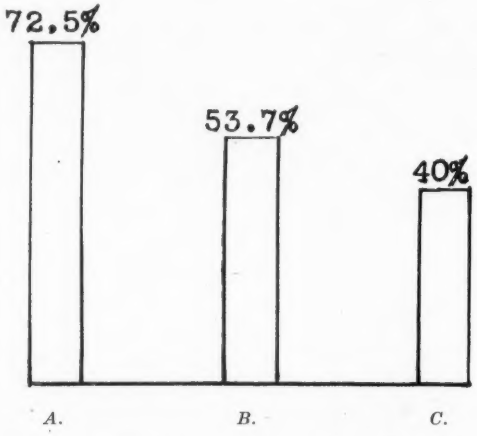

Fig. 14.—Case I M. Per cent of bolus passing through 100-mesh screen. *A*, 20 degree posterior teeth; *B*, DeVan posterior teeth, and *C*, Hall posterior teeth.

CASE II A.—*Results of Chewing Tests With Carrots:* About 5.2 grams were diced into approximately ⅜ inch squares. Twenty-five masticatory strokes were permitted for each mouthful. The particle size resulting from the use of the DeVan and Hall posterior teeth is about the same, while the particle size resulting from the use of the 20 degree posterior teeth is more uniformly and finely ground (Fig. 15).

Results of Chewing Tests With Peanuts: Approximately 5.2 grams of shelled roasted peanuts were used to conduct these tests. As with the carrot the patient was allowed twenty-five masticatory strokes for each mouthful. (Fig. 16).

The masticated bolus of peanuts was weighed after screening with the results shown in Table II.

TABLE II. CASE II A

TOOTH TYPE	WGT. PEANUTS CHEWED (Gm.)	WGT. PEANUTS RECOVERED (Gm.)	WGT. PEANUTS PASSING THROUGH 100-MESH SCREEN (Gm.)	% PASSING THROUGH SCREEN
DeVan	5.2	3.66	1.54	29.4
Hall	5.2	3.5	1.7	36.2
20 degree	5.2	1.98	3.22	61.8

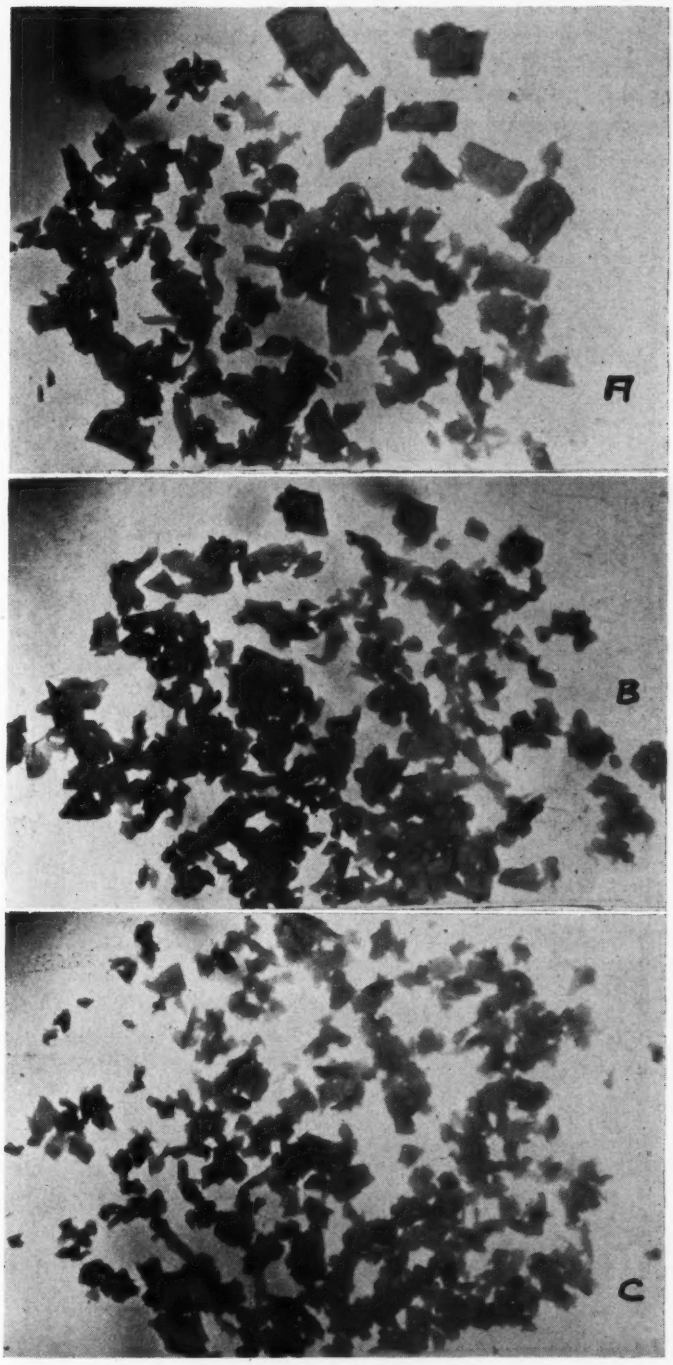

Fig. 15.—Case II A. The particle sizes of carrots after twenty-five masticatory strokes. *A*,, With DeVan posterior teeth; *B*, with Hall posterior teeth, and *C*, with 20 degree posterior teeth.

On the basis of weight checks the 20 degree posterior teeth were 32.4 per cent more efficient than the DeVan posterior teeth and 25.6 per cent more efficient than the Hall posterior teeth (Fig. 17).

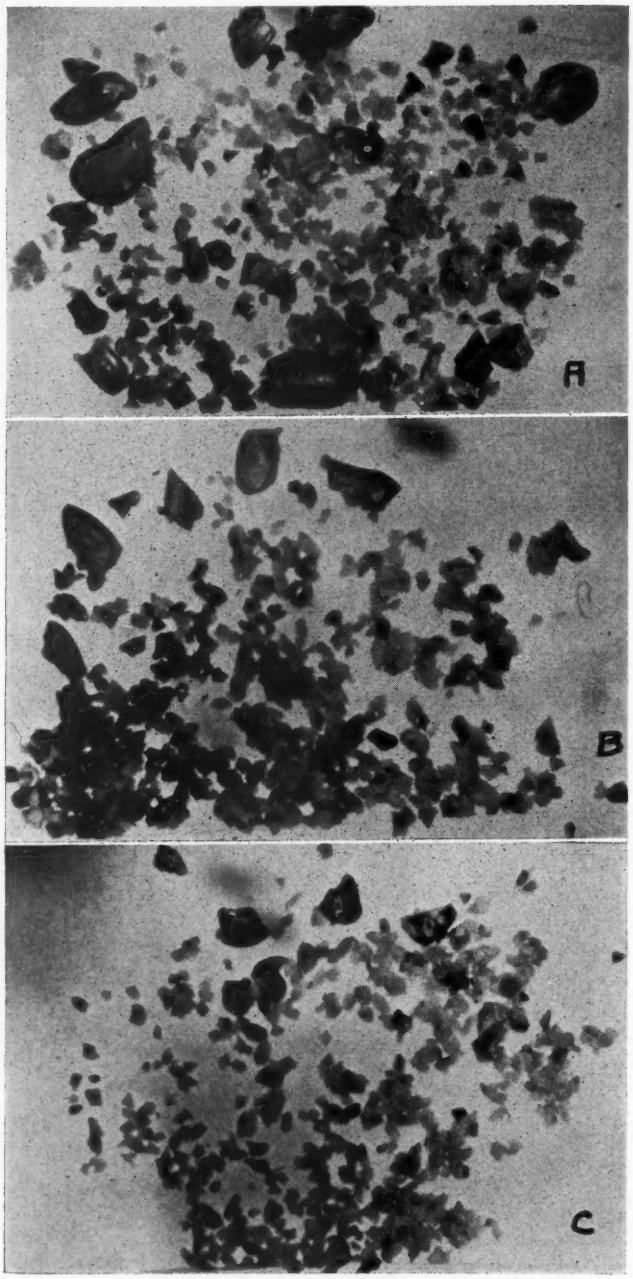

Fig. 16.—Case II A. The particle sizes of peanuts remaining in the 100-mesh screen after twenty-five masticatory strokes. *A*, with DeVan posterior teeth; *B*, with Hall posterior teeth, and *C*, with 20 degree posterior teeth.

It should be noted that the relative particle size which resulted in the chewing tests made on both patients remained rather constant for each patient. In Case I M the particle size for both carrots and peanuts was about the same when using the DeVan and 20 degree posterior teeth and somewhat more finely ground when using the Hall posterior teeth. In Case II A the particle size was about the same for carrots and peanuts when using the DeVan and Hall posterior teeth, and somewhat more uniformly and finely ground when using the 20 degree posterior teeth. In other words, the particle size remained relatively uniform for each type of food and type tooth used to masticate the food.

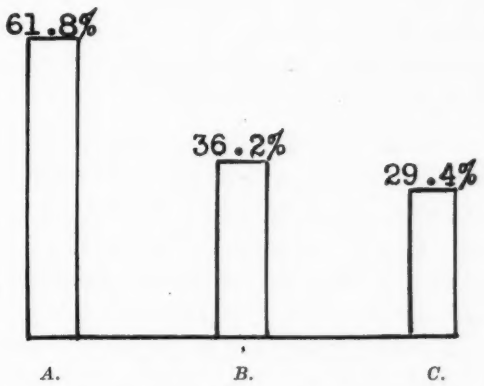

Fig. 17.—Case II A. Per cent of bolus passing through 100-mesh screen. *A*, 20 degree posterior teeth; *B*, Hall posterior teeth, and *C*, DeVan posterior teeth.

TISSUE REACTION AND PATIENT COMMENT

Case I M.—During the first cycle ulceration of the lingual frenum occurred while wearing the DeVan posterior teeth.

The ulceration became greatly increased while wearing the Hall posterior teeth. Relief of the denture in this area seemed advisable. This was the only denture adjustment made. The patient was instructed not to wear the denture for twenty-four hours. At the end of this time the 20 degree posterior teeth were inserted. Progressive healing of the ulcerated area occurred.

During the second cycle when the DeVan posterior teeth were reinserted, there was a recurrence of the lingual frenum ulceration together with irritation on the right side along the mylohyoid ridge.

When the Hall posterior teeth were inserted, ulceration of the lingual frenum increased as did the soreness along the mylohyoid ridge. With the 20 degree posterior teeth in place, only very slight irritation of the lingual frenum persisted and it disappeared in the mylohyoid area.

Patient reaction and comment recorded at the end of each 48-hour period during both cycles was as follows:

During the first cycle with DeVan posterior teeth: Dentures tend to "dislodge" during mastication. "Have sensation of fullness" and "not able to eat."

Hall posterior teeth (first cycle): "Could not eat with the dentures because of soreness, but the sensation of fullness has disappeared."

Twenty-degree posterior teeth (first cycle): "Retention during mastication is improved." "Dentures have good feeling, are comfortable," and the patient is "relaxed."

During the second cycle with DeVan posterior teeth: "Teeth won't cut food." "Can't bite properly." "Can't wear the dentures at night." (Note that in the chewing tests, the particle size was about the same as that when using the 20 degree posterior teeth.)

Hall posterior teeth (second cycle): "Can't eat with them, but they are better than the last set" (DeVan posterior teeth). "Can wear dentures at night." (Note that in chewing tests particle size was more uniform and finely ground than with either DeVan or 20 degree posterior teeth.)

Twenty-degree posterior teeth (second cycle): "Over-all feel of the teeth is better than the others. Most satisfactory of any."

CASE II A.—While the patient wore the DeVan posterior teeth during the first cycle, ulceration occurred on the right side of the lower ridge lingually and buccally in the first bicuspid area about 2 mm. below the crest of the ridge.

No relief was made for this ulceration. The Hall posterior teeth were substituted, and it was found that the ulceration became much more marked. Without making a denture adjustment, the 20 degree posterior teeth were substituted for the Hall posterior teeth. Marked improvement of the ulcerated area was noted within forty-eight hours. When the cycle of tooth changing was repeated for the patient, the same pattern of ulceration started with the DeVan posterior teeth, became more accentuated with the Hall posterior teeth, and tended to disappear with the 20 degree posterior teeth.

As with Case I M, the patient reaction and comment was recorded at the end of each 48-hour period, during both cycles. Comment was quite generally the same. In regard to the DeVan posterior teeth, the patient stated that his mouth felt "too full of teeth" and that the "teeth rock around." In regard to the Hall posterior teeth he said, "Must chew too hard" and "have to fight them too hard." The 20 degree posterior teeth "were stable and can chew with them."

SUMMARY AND CONCLUSIONS

The main objective of this experiment was to determine the possibility of testing occlusal tooth pattens and occlusions by using a common base for all occlusal changes. The advisability and accuracy of this procedure has been demonstrated. Further studies by this technique will do much to clarify the possibilities offered by the use of various occlusal patterns, occlusal concepts, and the efficacy of different types of articulations. It is hoped that this study may serve as an incentive to others to carry on similar experiments with controlled bases.

In Case I M, the carrots were more finely ground with Hall posterior teeth than with DeVan and 20 degree posterior teeth, which were about the same.

In Case II A, the carrots were more finely ground with the 20 degree posterior teeth than with the DeVan and Hall posterior teeth, which were about the same.

In Case I M, the chewing tests with peanuts showed that the 20 degree posterior teeth were 18.8 per cent more efficient than the DeVan posterior teeth and 32.5 per cent more efficient than the Hall posterior teeth. In Case II A, they showed that 20 degree posterior teeth were 32.4 per cent more efficient than the DeVan posterior teeth and 25.6 per cent more efficient than the Hall posterior teeth.

The greatest amount of tissue ulceration was produced by the Hall posterior teeth. Less tissue ulceration was caused by the DeVan posterior teeth, and the least by the 20 degree posterior teeth. Both patients preferred the 20 degree posterior teeth. No conclusion should be drawn from this limited number of chewing tests.

We wish to acknowledge and thank Dr. Henry Hatcher, Chief of Dental Service, Bay Pines Veterans Administration Hospital, for the use of the station facilities to carry on this work.

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DISCUSSION

An Experimental Study of the Testing of Occlusal Patterns on the Same Denture Bases, by Vincent R. Trapozzano, D.D.S., and John B. Lazzari, D.D.S.

DAVID W. MCLEAN, D.D.S.

Arcadia, Calif.

WHILE in Milwaukee for the sessions of the American Board of Prosthodontics, I was privileged to spend an evening with Dr. V. R. Trapozzano and Dean Fred Elliott of the University of Texas, in discussion of Trapozzano's paper. I was impressed then, and still am, by the tremendous amount of work Trapozzano has put into this project. Moreover I had then, and have now, nothing but commendation and appreciation growing out of the fact that Trapozzano has revived interest in this most important field of research—the efficiency of various tooth forms in mastication.

In Milwaukee, Trapozzano stated that he had received his first impetus from what he felt to be an error in my own procedures in carrying on a similar research for the Academy of Denture Prosthetics some years ago. It was his understanding that I had duplicated casts for the eleven pairs of dentures from the original master casts. This was an error due to the unfortunate fact that the research was reported only verbally, by motion pictures and still slides, and demonstration with the patient, before the Academy. The Academy then had no mechanism for bringing the report to the general literature of the profession and I take blame for not having devoted additional energy to the subject to get it down in black and white and submit it for general publication.

Trapozzano has approached this same problem from another angle. He uses anterior teeth coordinated to the posterior teeth being tested, and introduces them by a most ingenious technique to the denture bases so that the same denture bases are used throughout the experiments. I believe this satisfies the requirements for a research.

The only thing I would criticize about Trapozzano's procedure is the use of 20 degree cusp teeth as the norm by which he evaluates the chewing efficiency of the other types used. In my estimation, the full cusp tooth, in other words, nature's unworn tooth, should be the norm, rather than the replica of a badly worn tooth. It is true that the first one thousand miles of wear of a new automobile "wears it in." There is an indeterminable point somewhere in the course of this wear when "wearing in" stops and "wearing out" begins. The same thing is true of teeth. The amount of wear represented in 20 degree teeth would, for most patients, seriously reduce coordination. Moreover, a glance at 20 degree teeth shows their cutting blades to be "worn" flat and dull.

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Trapozzano said his choice of the 20 degree cusp was based on the thought that this tooth is used so extensively by the profession that it would make a good basis for comparison. I still feel this is not good logic for the basis of such a research. I can't conceive that the 20 degree cusp tooth is so extensively used; we have no data to base it on beyond the manufacturer's advertising claims, and it is my hope that Dr. Ralph Boos will make a survey of a large number of denture prescriptions to determine the percentage of 20 degree cusp teeth used as compared with full cusp teeth. In any event I think such a research should be based, from the standpoint of scientific criteria for evaluation, upon the chewing unit which Divine Providence evolved through many million years of progress from lower forms to the type manifested in the higher apes and man.

Trapozzano states that the method we used in our research limited our ability to keep track of the amount of peripheral trimming done. The contrary was true. We found that the 45 degree cusp teeth required almost no peripheral trimming during the "breaking in" period allowed before making efficiency tests and breaking in the next dentures.

The French posterior teeth required more trimming in the masseter areas, and the Hall posterior teeth required still more. After all three pairs of dentures were acceptably adjusted to the peripheral muscle action in mastication, we returned the 45 degree dentures to the master casts and blacked in the area trimmed off; the area of additional trimming required by the French posterior teeth was filled in with blue pencil, and a still further additional area required for Hall teeth was filled in in red. The master casts were then photographed in Kodachrome to show the areas graphically, as an indication of the increased force required to masticate food with the latter types of tooth.

One thing I particularly want to commend Trapozzano for is the renewing of interest in this important question of how efficiently posterior tooth forms chew. By some rather screwy process, our thinking regarding posterior artificial teeth seems to be deflected into two or three rather extraneous channels. First, and of some importance it is true, is the protection of the denture support. While that is important within limitations, I believe a patient will end up in better health at 80 years of age if he has had efficient chewing equipment through the entire period than he will if he is given teeth of less chewing efficiency which will be easier on the supporting ridges. Second is the attempt to eliminate cuspal interferences by eliminating cusps entirely, rather than by coordinating them.

I was appalled by a concept that teeth shear so little in chewing that shearing efficiency is unimportant, and that teeth do not actually contact during mastication but merely "approximate." This newest development in the philosophy of mastication seems to have arisen from the excellent work Dr. Bernard Jankelson did with fluoroscopic motion pictures at the University of Washington. I talked with Jankelson in February about his procedures and asked if he had evaluated the occlusion of his demonstration patients in advance, in search of interferences which might influence the rhythm and extent of masticatory movements. He replied that he had not.

A motion picture "Physiologic vs. Pathologic Occlusion" was produced by me some three years prior to the research mentioned by Trapozzano. That earlier

picture analyzed the chewing cycle and tooth contacts during chewing with natural posterior teeth well coordinated by nature.

This picture appears to have established, for the first time, that on the working side of the functioning dentures, the so-called "balancing cusp contacts" become important working contacts in shearing food, while at the same time so-called "working contacts" are acting as "balancing contacts" on the balancing side of the mouth. In the perfectly functioning case, there are contacts on both the balancing and working sides during the entire shearing stroke from one lateral terminal position through centric to the other lateral position.

After the picturization of this patient chewing Dentyne gum under instruction to "chew it hard," other patients with varying degrees of noncoordination were similarly studied and picturized, leading finally to a patient whose occlusion was so locked by interfering cusps that he could only chop straight up and down. It was definitely established that *it is the degree of cuspal coordination and not the food worked upon* which determines the shearing stroke of the mandible. It was definitely a shock to hear a dentist say not long ago that the shearing stroke is quite different when chewing gum (which he classed as "recreational chewing") than when chewing meat! We have studied the shearing action of teeth on several different foods, both pulpy and fibrous, and wish to state definitely that the character of the food influences only the forcefulness and perhaps the length of the shearing stroke. There is a typical shearing stroke if cusp arrangement is such as to permit it.

It is true that there may be any number of macerating and crushing strokes before shearing starts. When some intricate tactile sense in the periodontal membranes, perhaps aided by nerve end organs in other oral soft tissues, determines that the bolus is sufficiently reduced for shearing, then shearing starts. The direction of shearing strokes will depend upon cusp ridges, the individual mandible's factors of motivation, and other factors of control. The length of shearing strokes will depend upon the presence and degree of cuspal interference. The number of shearing strokes will depend on three factors: the difficulty of the food being comminuted, the patient's laziness, and his haste.

Let us grant at once that the average individual does not chew nearly enough. Jankelson's motion picture corroborated that. You will be surprised if you will take a stop watch into a restaurant and time your neighbor's chewing. When a bolus of food is placed in someone's mouth start your watch and at deglutition stop the watch. The timing will surprise you. This does not mean that we need not give the patient efficient dentures to chew with; perhaps it means we should give him the *ultimate of efficiency* so that the little chewing he does may count!

Another point that should be discussed is the reliability of data acquired by means of a patient's chewing. While the patient was chewing with various pairs of dentures at the Houston meeting, with the Fellows of the Academy of Denture Prosthetics looking on, Dr. Merrill Swenson remarked that such tests were not of any value, because the patient could not be relied upon to chew with the same vigor, speed, and force throughout all of the tests. This seemed at the time a most discordant note. Subsequent observations have convinced me, however, that Swenson was correct. On different occasions, the patient may apply different de-

grees of force and thoroughness in the masticatory strokes. Even on the same occasion, the patient may apply different degrees of force to one part of the chewing with a single pair of dentures or toward the close of the series, because of fatigue.

I have long advocated the development and use of a machine which would chew with a definite, regulatable force and speed. In our informal discussion of the subject in Milwaukee, Trapozzano, Elliott, and I all conceded the extreme difficulty of creating such a machine. At that point Elliott suggested that such a machine would not have to reproduce the entire chewing mechanism. He pointed out that many efficiency tests used in industry *simulate* the forces and wear the material or object is to be subjected to in actual use. This would mean that a machine could be made, with one or two pairs of molars, to apply crushing pressure and one shearing stroke repeated indefinitely for as long a period as desired. Some sort of flexible rubber straps would be necessary to keep the food between the chewing surfaces and to return it to a position between chewing surfaces after each jaw stroke as the tongue and cheeks do. Such a testing machine would give a clear and dependable index of the efficiency of the type of tooth being tested. The developing of such a machine would be an excellent project for some university or other organization with available means and personnel.

Certainly, if any phase of dental science and practice calls to heaven for clarification, it is the one to which Trapozzano has made this fine contribution. In again commending him, may I also urge that others join in this research. It is not until a number of research men, in various separated areas, perform the same tests and begin to come up with the same results that we will have a really dependable basis for clinical practice.

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EQUILIBRATED FUNCTIONAL OCCLUSIONS

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COMPLETE denture construction has challenged the knowledge, ability, and ingenuity of our profession. It has presented many problems and, because of their complexity, many have never been fully solved. It is the purpose of this paper to call attention to only one of these problems, namely, the instability of the artificial denture base during function. There have been numerous attempts to solve this problem; better and improved impression techniques have been developed. These have helped to provide for more stability, but only to a limited degree. Various occlusal forms of artificial teeth and systems of articulating those teeth have been developed. These were designed to eliminate lateral stresses which may contribute to the instability of the denture bases.

The recording of the centric occlusal relation has perhaps received more attention than any other step in the procedure of complete artificial denture construction. It has long been observed that when "the bite has been missed," a shifting of the denture base is apparent when the patient attempts to put the teeth into occlusion. There is much controversy concerning the methods used to record the centric occlusal relation. There is also much controversy concerning what constitutes the centric occlusal relation. It is at this point that the missing link occurs. What is the relationship of the denture base to its supporting tissue structures during the recording of the centric occlusal relation?

To produce comfort for the patient, it is well to understand what produces discomfort. The greatest single factor which creates discomfort for the edentulous patient using artificial dentures is the factor of displacement of not only the denture bases over the supporting tissues but the displacement of soft tissues over the supporting bone.

It should be noted that a patient masticates his food not much more than one hour a day, but he is continually closing his teeth together during the day and part of the night. During the process of mastication and while the bolus of food is between the teeth, the resultant stresses are in all planes. At this time, the fit of the denture bases, and their inclusion of areas which will prevent a horizontal and vertical displacement, and the musculature of the facial tissues and tongue are the only stabilizing factors. The occlusion of the teeth has not yet come into play. When the teeth have gone through the bolus of food and come into contact, or nearly so, they play a vital part in the stabilization of the denture bases or in their displacement.

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For the sake of clarity, let us consider the centric and eccentric occlusal relations separately. We must also distinguish between centric occlusion and centric relation of the mandible to the maxilla. Centric relation is the relative position of the mandible to the maxilla when it is at rest. At this physiologic rest position, the mandible will exhibit mandibular centricity. In other words, the heads of the condyles of the mandible will be resting comfortably in the glenoid fossae. Centric *occlusal* relation is the contact relationship of the mandibular dentition to the maxillary dentition concurring with mandibular centricity. It must provide for an acceptable denture space which in turn will allow for a free-way space which exists between the position of centric relation and centric occlusal relation. It must also provide for functional equilibration of the occluding teeth.

Many volumes have been written on centric occlusion, its definition, and techniques to obtain it. Most writers have stressed its importance and, in the techniques they describe, they point out the hazards of denture baseplate displacement. It is interesting to note that there are two schools of thought concerning the method in which the recording of centric and eccentric occlusal relations should be obtained. One school of thought believes that these recordings should be secured with as little stress as possible. The other believes that functional stress should be used at all times. It is also interesting to note that both these schools of thought have prescribed various locations for the placement of intervening stops which are used to maintain the denture space and to record centric and eccentric occlusal relations. Many materials, such as waxes, compounds, plaster, plaster and carborundum, pastes, etc., and many devices have been and are being advocated. These devices consist mainly of central bearing devices of many forms, spring devices, and chew-in devices. It is conceded today by most prosthodontists that the Gothic arch tracing is the most reliable means of determining mandibular centricity. Some insist that a functioning centric occlusal relation is slightly protrusive to that which is obtained by a true Gothic arch. Others maintain that true centric relation does not require that the tracing pin be at the apex of the Gothic arch, but that it may be laterally upon one of the segments of the arch. Still others insist that the Gothic arch is not a true indication of mandibular centricity.

Since there is so much confusion and disagreement as to what method is correct and practical, let us investigate the aims and purposes of the advocated procedures. It is quite generally agreed that the accepted method should fulfill the requirements of centric occlusion in the finished dentures. These requirements are: (1) Mandibular centricity or, in other words, the heads of the condyles must be in their most posterior rest position in the condylar fossae, from which lateral movements of the mandible may be made. (2) A denture space or vertical dimension which provides for an acceptable free-way space. (3) A functional equilibration of the occluding surfaces.

Inasmuch as we are agreed as to our objectives, let us investigate what has given the profession so much trouble and disappointment in securing these objectives. The following is an example of this difficulty. Centric occlusion was recorded with the aid of a Gothic arch tracing. Upon completion of the den-

tures, it was found that centric relation had been missed. Centric occlusion was not concurring with mandibular centricity. That is, when the mandible was allowed to relax back to the head, and the denture bases were firmly seated, the teeth did not mesh properly.

A few pertinent mishaps could have caused the error. Perhaps the most common cause is improperly fitting trial plates or baseplates. One cannot obtain a proper recording of centric occlusal relation with baseplates that are easily displaced because of lack of fit. A baseplate may fit the cast perfectly, and thus fit the patient's ridge perfectly when it is put into the mouth but, because of the character of the material of which the baseplate was made, it no longer fits either the cast or the ridge in the mouth when it is removed from the mouth and placed on the cast.

Even with stabilized, well-fitting baseplates, one cannot be assured of centric relation by a Gothic arch tracing. These baseplates, however well they fit on the displaceable tissues covering the ridge, may be displaced by the method by which the centric occlusal relation is recorded.

Of course, those ridges which present a considerable amount of displaceable tissue create the greatest problem, and it with these ridges that we are most concerned. But all ridges demonstrate placeable tissue to some extent. It is in direct proportion to the amount of this movable tissue, and to the degree of its movement, that a well-fitting baseplate can be shifted on the ridges by forces used in recording intermaxillary relationships.

This shifting or displacing of the baseplates during the recording of the centric occlusal relation precludes the reliability of a Gothic arch tracing. This is because a Gothic arch tracing, with distinct intersecting arches, can be made with baseplates that have been displaced, or with baseplates which have deranged the movable tissue of the ridges. An explanation of the above statement is that the scribing of a true Gothic arch is dependent upon the condyles of the mandible being in their most retruded position in the condylar fossae. When lateral excursions of the mandible are made from this position, true arches will be scribed regardless of the location of the baseplates on the ridges. It is readily seen then that, under the above conditions, a true centric relation of the mandible to the maxilla may exist without a true relationship of the baseplates to the ridges.

It has been suggested by some that the conditions just described can be overcome by securing impressions that will not displace any tissue, and will have a precise tissue contact. It is said that these impressions will create bases which are so stable that displacement is negligible. It is recommended that the recording of centric occlusal relation be made on accurate metal castings which are made from the impressions, or be made on the impressions themselves.

This is a step in the right direction, but I submit that, even though the bases were cemented to the ridges, the conventional methods used to secure intermaxillary relationships would not provide the same correlation of the bases that will exist when the dentures are completed and are in function in the mouth. Is this functional correlation of denture bases necessary to successful artificial denture construction? My own observations, and the observations of many others,

lead me to believe that the lack of functional relationship of the denture bases and, therefore, lack of functional centric occlusion is the greatest factor contributing to the discomfort of the patient and to the lack of masticating efficiency. When I speak of discomfort associated with pain and masticating inefficiency, I am not speaking of the patient who can be satisfied with almost any excuse for an artificial denture. You have seen them and I have seen them, but I am speaking of the thousands of patients who have tissues covering their ridges which cannot withstand the trauma resulting from constantly displaced denture bases. It is especially for these patients that the dental profession should give more serious thought to this problem.

I have previously stated that an acceptable centric occlusal relation should provide a functional equilibration of that occlusion. In other words, when the dentures are in centric occlusion and force is exerted, that force should be distributed evenly throughout the contacting surfaces of the occluding teeth. Then and only then will the force be transmitted uniformly to the supporting areas of the ridges.

The direction of force of the various muscles of mastication combine their efforts to produce a resultant of these forces. Pruzansky[1] states, "Every day and in many ways, the dentist must cope with sensory and proprioceptive disturbances which modify the motor activity of the muscles of mastication and the function of the temporomandibular articulation. For example, the patient with a high spot on a newly cemented inlay soon finds that his pattern of chewing is changed. Individuals with malposed teeth, periodontal ailments and those with prosthetic appliances are consciously and unconsciously adjusting the neuromuscular control of the temporomandibular articulation as a consequence of altered peripheral stimuli. The central nervous system integrates the pattern of masticatory movements with the anatomic factors present." It is this neuromuscular control of the synergistic action of the muscles of mastication which may produce many different directions of the resultant of force. It is also possible that this neuromuscular control is the reason why many patients can manage and juggle ill-fitting artificial dentures.

The positions of the various muscles of mastication in their relationship to the ridges of the maxilla and mandible create a different direction of the resultant of force for an artificial denture occlusal plane than it would create for an occlusal plane of a natural dentition. This is true because the denture base is movable on the supporting tissues, and the supporting tissues are displaceable on their bony support, while in the natural dentition the whole assembly is more or less solid.

This direction of the resultant line of stress of the muscles of mastication plays a dominant role in the placement of maxillary and mandibular denture bases from a nonfunctional position to a functional position. Clinical observation of artificial dentures, constructed with conventional techniques, has taught us to expect denture bases to settle into a functional position but, in so doing, centric and eccentric occlusions are lost.

For many years, our Portland prosthetic study clubs used a method of equilibrating the occluding occlusion rims during the process of recording cen-

tric occlusion. This method, developed by Dr. E. K. Peters, secured an equilibation without stress. Although it was very time consuming, it was a definite improvement over methods which did not provide for an equilibation, but it still lacked the means to provide a uniform distribution of stress over the supporting tissues of the ridges during function.

It occurred to me that some mechanical device would solve the problem. I was aware of the advantages of the central bearing device, the advantage of having a central bearing screw to maintain intermaxillary space, and at the same time keeping the bases seated against the ridges. I was also mindful of the advantages of an equalization of intermaxillary stresses. It then was my object to combine this desirability of equalization or distribution of forces with the expediency of the central bearing device, and at the same time secure the registration of the centric occlusal relation under functional stress.

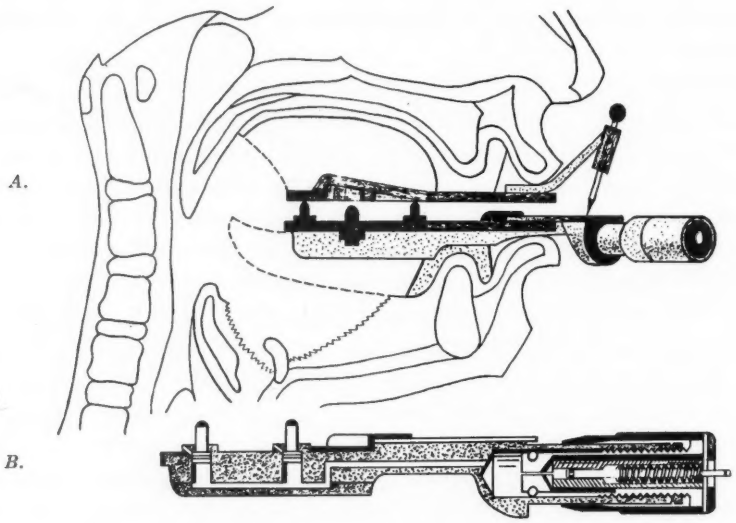

Fig. 1.—*A*, Sagittal sectional drawing of the equilibrator in the mouth. Within the maxillary member or striking plate is an inclined plane recess which provides for an opening component in eccentric positions of the mandible and allows for better indexing of the plaster check bite records used.

B, Sectional drawing showing the hydraulic system used. The master cylinder is connected to all four smaller cylinders by a common channel or tube. Only two of these cylinders of one side are shown in the diagram. The piston of the master cylinder is drilled through to receive a smaller piston within. This smaller piston, restrained by a spring, acts as an indicator of the pressure exerted by the patient.

THE EQUILIBRATOR

A practical device which would incorporate the above advantages must of necessity be simple in its operation and, therefore, not too time consuming. Patient cooperation is more readily secured if the operation of registering jaw relationship can be done quickly and efficiently.

The principle of the hydraulic brake as used on your car is based upon a law of physics, that is, Pascal's law. It may be stated as follows: "Pressure exerted anywhere on a confined liquid is transmitted undiminished throughout the interior

of the containing vessel." It is this principle applied to a central bearing device which will enable the patient to apply force, equally distributed, while the dentist obtains a registration of centric occlusal relation of the mandible to the maxilla. As we all know when one steps on the brake pedal of a car, the pressure is transmitted equally to the brakes of each of the four wheels of the car. In a like manner, the device which I am about to describe will transmit an equalized pressure to the tissues supporting the denture bases (Fig. 1).

As included in the mechanism of the hydraulic brakes, the equilibrator has a master cylinder connected to four actuating cylinders by means of channels or tubes. The pistons in the actuating cylinders are provided with rods that emerge from the appliance, and contact a metal striking plate which has been placed on the upper baseplate. It is the uniform pressure of these four rods against the upper striking plate which produces a favorable seating of the bases, because it will place the movable tissues in the same position as will the finished dentures under function, and at the same time will distribute the resulting stress evenly over the surfaces of the ridges. Since the rods approximate the bicuspid and molar positions on each side, and since the actuating force is created by the patient, a very similar resultant force as that produced by use of the finished dentures is transmitted to the supporting tissues. A tracing table is fitted to the lower member of the appliance, and a tracing pin is attached to the upper member. A central bearing screw is provided to maintain the maxillomandibular opening or vertical dimension. Within the center of the upper striking plate is included a recessed inclined plane. An opening component is produced when the central bearing screw rides across this inclined plane during the eccentric movements of the mandible. Protruding from the handle of the master cylinder is a pressure indicator. This indicator informs the operator when the equilibrating studs are in function and when the central bearing stud is out of contact (Figs. 2 to 8).

The procedure for registering centric occlusal relation is as follows: The denture space or maxillomandibular opening is established, and an approximate centric relation is secured. These records are used to mount the casts on an articulator (Figs. 9 and 10). A great amount of care must be used in the construction of the baseplates. In order that baseplates may be removed from the casts and replaced accurately, it is necessary to block out all undercuts that exist in the casts. This is done by filling in the undercuts with disintegrating plaster. Shellac baseplate material is adapted to the casts in the conventional manner, but it is well re-enforced with heavy wire; 1/1,000 tin foil is burnished over the casts, and further swaged to the cast by forcing the previously formed baseplates over it. The baseplates are then removed, allowing the tin foil to remain on the cast. A mix of self-curing acrylic resin is made, quickly placed into the baseplates, and immediately placed on the tin-foiled casts and forced to place. The result is baseplates that will not warp out of shape when subjected to temperature changes. It is superior to an all-acrylic baseplate because the amount of acrylic resin used as a corrective is small, and therefore is not subject to the volumetric change which is inherent in a larger mass of the self-curing acrylic resin. It must be remembered that the upper baseplate must not include the

Fig. 2.

Fig. 3.

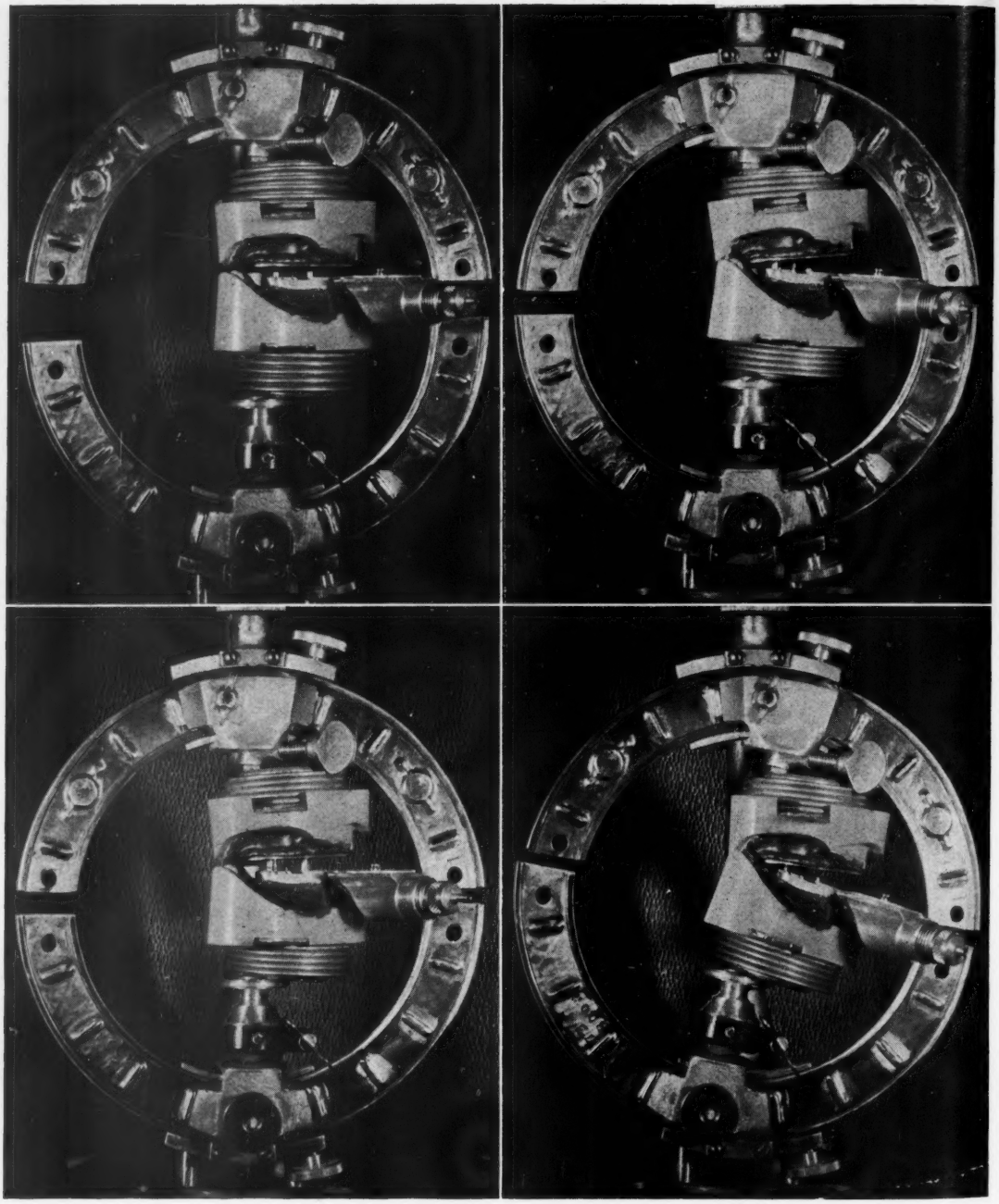

Fig. 4.

Fig. 5.

Fig. 2.—A device to demonstrate the effect of the direction of force upon baseplates, during the recording of centric occlusal relation. The upper half of the split ring is movable in a vertical direction, and is powered by a hand ratchet located at the top of the stand. The edentulous casts are mounted within the split ring by means of mountings which can be moved along the circumference of the ring. Between the casts and the mountings, there are interposed bellows springs of uniform compressibility.

Fig. 3.—Vertical pressure applied against a central bearing stud (sagittal view.)

Fig. 4.—Vertical pressure applied against equilibrating studs (sagittal view).

Fig. 5.—Diagonal pressure applied against a central bearing stud (sagittal view).

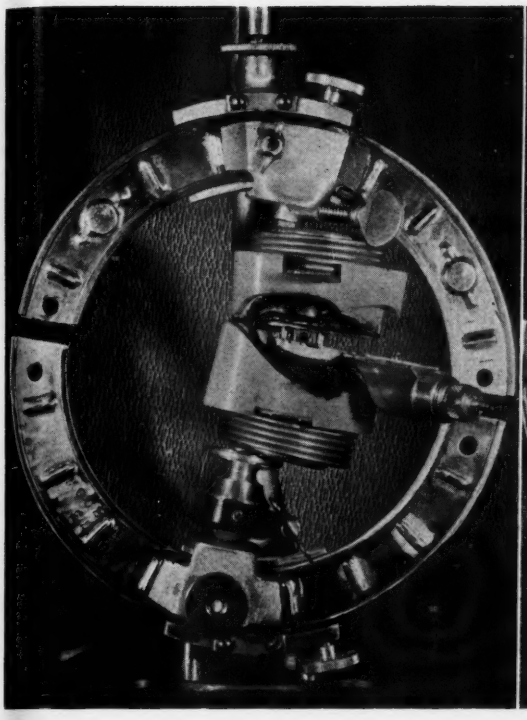

Fig. 6.

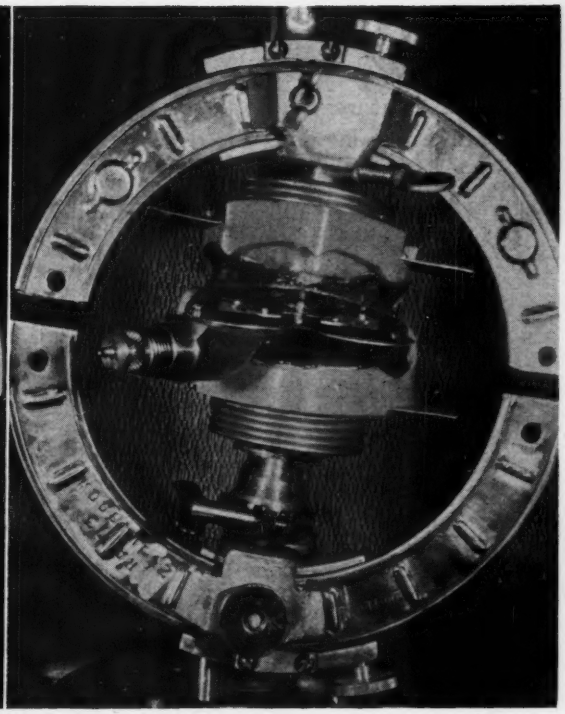

Fig. 7.

Fig. 6.—Diagonal pressure applied against equilibrating studs (sagittal view).
Fig. 7.—Diagonal pressure applied against central bearing stud (facial view).

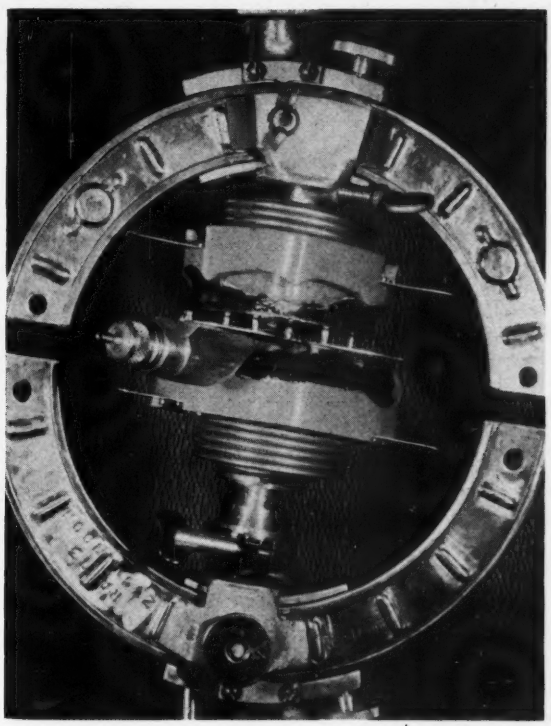

Fig. 8.—Diagonal pressure applied against equilibrating studs (facial view).

post dam area if the upper impression was post dammed in the mouth. If the post damming is to be done on the cast, this step is postponed until after the records of centric and eccentric relations have been obtained. Any post damming included in the upper baseplate will encroach upon displaceable tissue, which in turn will tend to displace the baseplate while recordings are made.

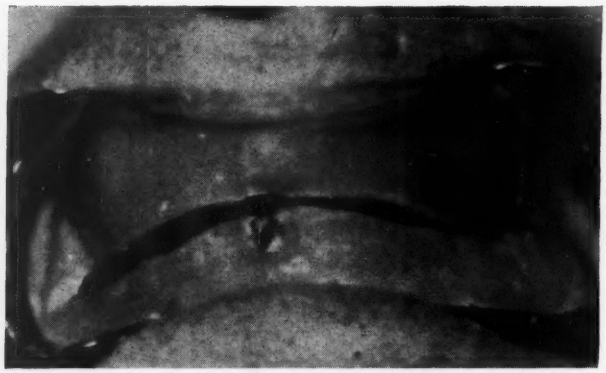

Fig. 9.—The approximate centric relation using soft modeling compound between the occlusion rims to create as little pressure as possible.

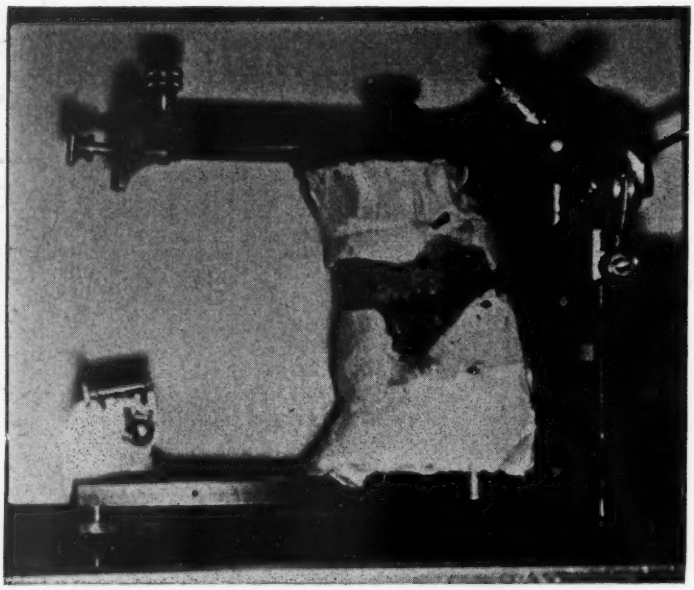

Fig. 10.—The approximate centric relation mounted in an articulator.

At this time it is well to check the parallelism of the casts as they are mounted in the articulator. They were mounted according to the approximate centric relation which included the vertical opening as dictated by the observance of free-way space. The more nearly the ridges are to being parallel, the more favorable will be the records of the jaw relations and the more stable will be the finished den-

tures. Since corrected and equilibrated centric occlusal relationship will be obtained subsequently, and the lower cast will be remounted to a new relationship, it is permissible to close the vertical dimension in the articulator at this time to provide for a closer parallelism of the ridges of the casts. In doing this, some of the esthetic effect may be sacrificed by shortening the vertical dimension.

Fig. 11.

Fig. 12.

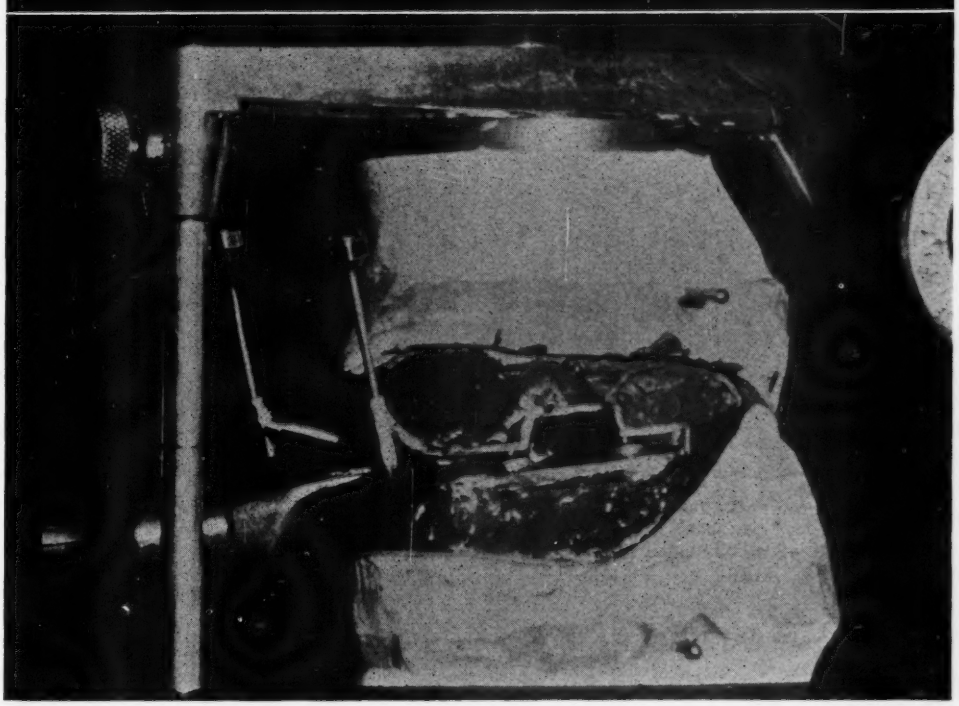

Fig. 11.—The equilibrator mounted on stabilized baseplates.
Fig. 12.—The equilibrator mounted in an articulator.

The equilibrator plates are attached to the baseplates so they are parallel to the casts and parallel to each other (Figs. 11 and 12). The central bearing screw is adjusted to maintain the denture space which was previously established in the approximate centric relation, and fixed by the incisal guide pin of the articulator. The tracing table on the lower member of the equilibrator is painted with machinist's scribing fluid, and the whole assembly is taken to the mouth of the patient for the purpose of making the centric and eccentric occlusal relation

Fig. 13.

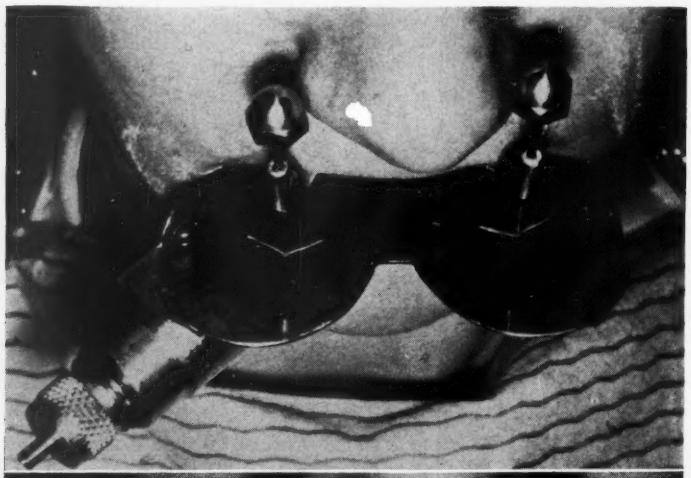

Fig. 14.

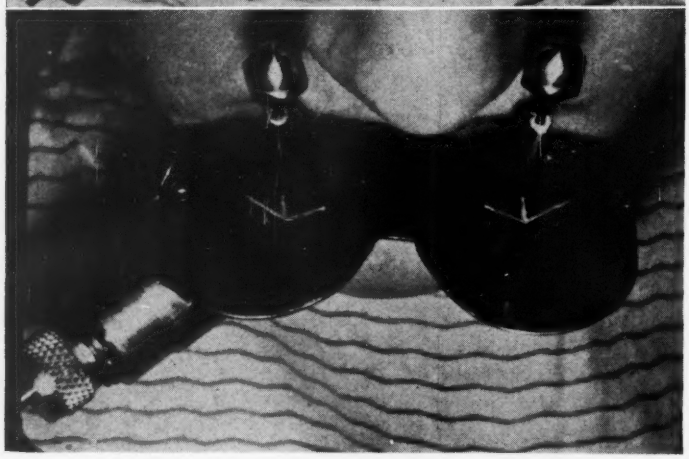

Fig. 13.—Recording centric relation with the equilibrator. The patient is creating functional stress and can hold the scribing pins at the apices of both the Gothic arch tracings because of the equalizing effect of the equilibrator.

Fig. 14.—Recording the protrusive relationship.

recordings. When the baseplates with the equilibrator attached are firmly seated in the mouth, the patient is instructed to close and keep firm pressure against the central bearing screw. The incisal path-marker pins are out of position at this time, since the patient must be trained before scribings are made. The patient is told to shift the mandible forward and backward a number of times, keeping light pressure against the central bearing screw. This is repeated until you feel

that he has allowed the mandible to drop back solid to the head. If you place your thumb on his chin you will be able to feel when both condyles drop back solid to the head. The patient also will be able to feel his jaw drop back to a stop in the region of his ears. When the mandible is back to its stops, the patient is instructed to shift the mandible to the right and back to the center, then to the left and back to center. After the patient is well trained in what is expected of him, the objective is to obtain a Gothic arch tracing while the baseplates are seated under equilibrated function. The tracing pin is put into position,

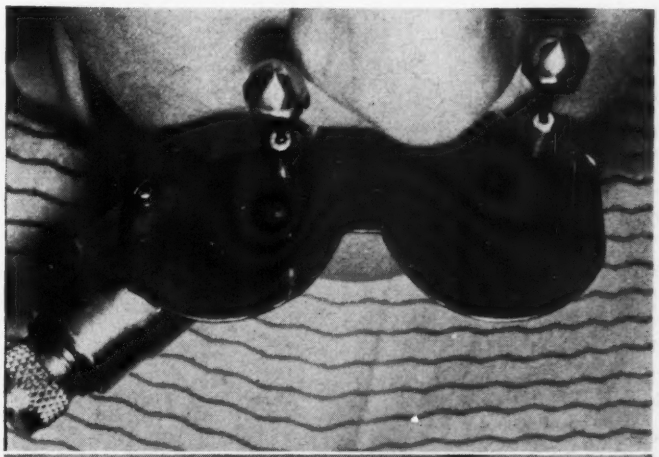

Fig. 15.

Fig. 16.

Fig. 15.—Recording the right lateral relationship.
Fig. 16.—Recording the left lateral relationship. The patient is holding both tracing pins on the lateral segments of the Gothic arches.

and the patient is instructed to close. At this time there will be contact between the central bearing screw and the inclined plane of the striking plate. The knob on the master cylinder of the equalizing appliance is turned up sufficiently to actuate the equilibrating rods on the lower member of the equilibrator. The patient must exert pressure at all times. As the knob is turned up, the contacting rods will seat the baseplates into a functioning position, and at the same time

will lift the striking plate off the central bearing screw. This will be detected by protrusion of the pressure indicator rod located on the handle of the master cylinder. While the baseplates are seated in this functional position, a Gothic arch tracing is obtained by calling upon the patient to move the mandible in the same

Fig. 17.

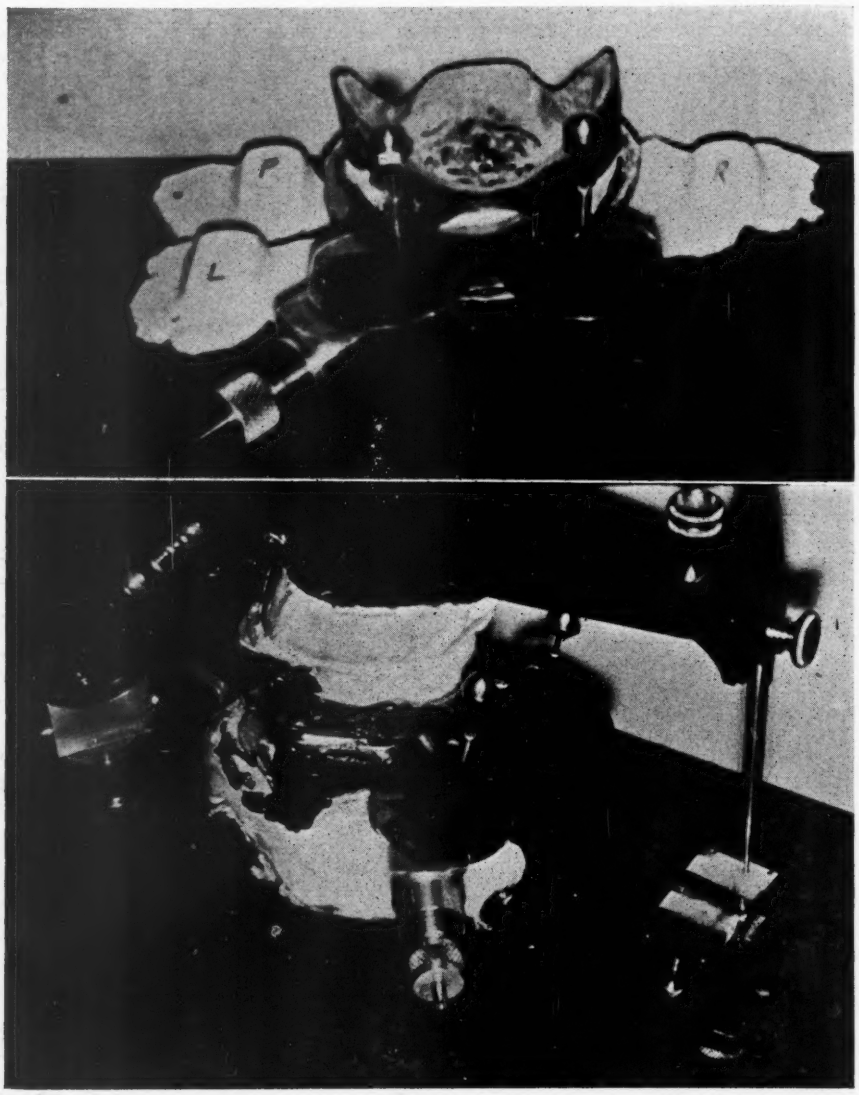

Fig. 18.

Fig. 17.—The equilibrator assembled with the centric plaster check bite. The protrusive, left, and right lateral check bites are shown at the sides.

Fig. 18.—The casts are remounted into the articulator to the equilibrated centric relation and the articulator is adjusted to conform to the registrations of the eccentric plaster check bites.

manner as he was previously instructed (Figs. 13 to 16). Centric occlusal relation is registered by means of a plaster or stone check bite when the tracing pin is at the apex of the Gothic arch tracing. The patient maintains pressure at all times, thereby establishing equilibration in centric occlusal relation under function. Eccentric relations are recorded in essentially the same manner (Figs. 17 and 18).

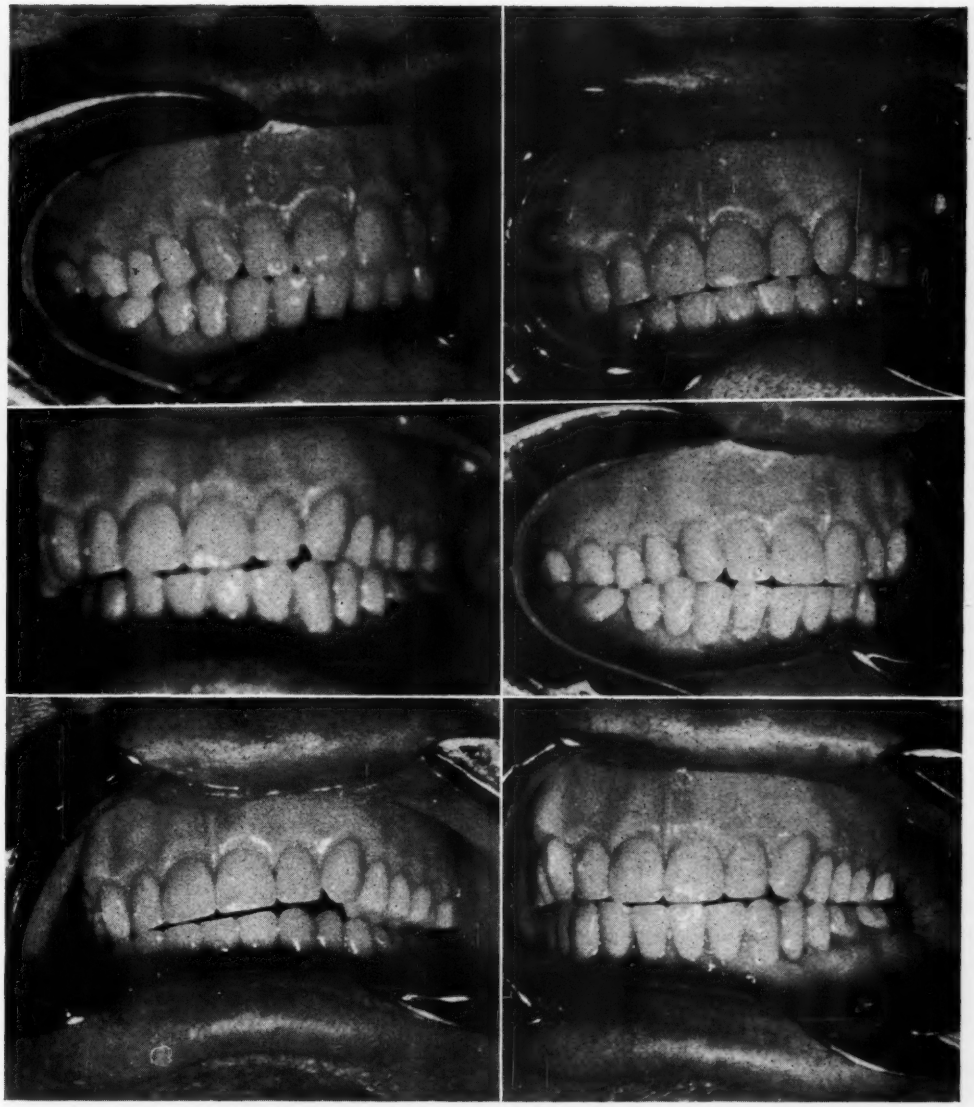

Fig. 19.—Equilibrated occlusions after two years of service. *A*, Centric occlusion (right side). *B*, Centric occlusion (left side). *C*, Working occlusion (left side). *D*, Working occlusion (right side). *E*, Balancing occlusion (left side). *F*, Protrusive occlusion.

SUMMARY

After experimenting for about three years with this principle of recording jaw relationships, it is my sincere belief that greater comfort and masticating efficiency can be obtained by its use (Fig. 19). I do not wish you to believe it is the answer to all stabilization problems, but I do believe this principle of functional equilibration merits investigation and further development. It is with this thought in mind that I have presented this problem and my meager efforts to solve it.

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BIOMECHANICAL PROCEDURES BASED ON ANATOMIC CONSIDERATIONS IN FULL DENTURE PROSTHESIS

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THIS paper is written with the thought in mind that even though one may be reasonably well satisfied with the present method of full denture construction, it should always be of interest to learn of the method employed successfully by someone else. I am aware of the fact that there are many techniques used in full denture prosthesis and that there probably is no "best" technique among the many that are acceptable. However, it is clear, after perusing current dental literature, that there is confusion of thought and highly varying interpretations of methods currently in vogue.

First, it is well to review the task at hand with the idea of starting the procedure with a definite purpose in mind. Then a sequence of events carried forth in an orderly and sensible manner with an ultimate goal in sight, being sound from a biomechanical point of view and in harmony with the anatomic limitations and physiologic tolerance of the structures, is possible.

The task of correctly restoring tooth function in the edentulous mouth is not a simple one. The operator must not only possess the ability to recognize the structural changes that have already occurred but he must also be able to visualize the tissues in their normal state prior to the loss. Then, dentures that fit comfortably, that are capable of adequate function accompanied by ease of manipulation, and that meet esthetic and phonetic requirements are within the realm of possibility. These accomplishments are not possible by the application of technical skill alone. A complete and thorough understanding of the normal as well as the altered anatomy of the areas involved is also necessary.

Loss of teeth may be due to a number of factors. Among the more common causes are age, trauma, and disease. Regardless of the cause, there are always ensuing structural changes in the bone and soft tissues. In the general development of the dental arches, the growth of alveolar bone forms the supporting structure for the teeth. Following the loss of teeth, there is a rapid resorption of this structure. It is observed that, in the maxilla, there is a much more rapid resorption of the external alveolar plate. In the mandible, there appears to be a fairly even degree of resorption between the internal and external plates. This is thought to be due to the much greater density of the mandibular bone.

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USE OF IMPRESSION TECHNIQUE

Regardless of the method employed for securing impressions, there are certain considerations that are fundamental. When establishing the limits of the peripheral borders for prosthesis, the impression technique must of necessity be adapted to the functional limitations of the neighboring facial and jaw musculature, the mucosal folds of the vestibule, and the floor of the mouth. An impression made while the muscles are at rest, or while they are held in a fixed position, is considerably different from one taken in a manner that records the functional excursions of the peripheral tissues. It is a well-known fact that displaced dentures are a certainty when the muscles are impinged upon. Current literature frequently refers to this fact, indicating that proper techniques are not always followed. It is evident that a clear knowledge of the locations and functions of the affected structures is lacking in many instances.

Fig. 1.—Pre-extraction casts.

In a recent article, Boucher[1] concluded, "The means employed in building an impression is of relatively little importance, except in regard to the impression problem of the individual. There is no single ('best') impression technique. The variety of impression materials, and the range of working characteristics of these materials, make possible the development of impression procedures best suited for the specific conditions in each area in a given mouth. Blindly following a technique will not produce the results which are possible by the critical analysis of the requirements of the patient and, therefore, devising a technique for that particular patient. A technique should be an orderly sequence, but not a dictator. The test for any impression is—does it do what it should do in every area?"

The following is a step-by-step procedure I am currently using. It is a combination of many ideas other than my own which have been observed and made use of over a period of years. If the reader finds that by the adoption of any one phase of this procedure his results will be improved, I shall be gratified.

At the first appointment, a three-phase examination of the oral cavity is made—radiographic, visual, and digital. It is amazing what full-mouth radiographic examinations of mouths thought to be properly prepared for the reception of dentures often reveal. It is estimated that, in about 30 per cent of these

cases, surgical intervention is necessary prior to the beginning of impressions. Correct surgery is so essential to successful prosthodontics that it is a nearly fatal mistake to fail to recognize this fact. For the operator who does not do his own surgery, there should be the closest cooperation between the prosthodontist and the oral surgeon. It is well to mention at this time, even though we are primarily discussing the edentulous mouth, that the failure to secure pre-extraction casts whenever possible is an all too frequent error. These pre-extraction casts contain a wealth of information, the most significant part of which is an accurate vertical measurement (Fig. 1).

PRIMARY IMPRESSIONS

Preselected impression trays, best suited to the task at hand, are used to carry impression material of choice to the mouth for an initial impression of each of the mandibular and maxillary ridges and all areas, recesses, structures, and attachments pertaining thereto. These impressions are greatly extended, purposely, beyond all limitations of anatomic and physiologic tolerance that will be incorporated within the peripheral borders of the finished dentures. A low-fusing impression compound is my material of choice for this initial procedure. However, equally acceptable primary impressions may be obtained with other materials. The material of choice should be the one the individual operator thinks is most workable in his hands, and at the same time satisfies all the requirements of the primary impressions.

By simple fashioning of the material being used into the tray selected, satisfactory results should be the product of this procedure with only one insertion of the impression material for each primary impression. From these impressions our primary casts are made.

OUTLINING THE CASTS

It is of utmost importance that we have a thorough understanding of the anatomy of the structures involved, as well as their physiologic tolerance. This is a phase of the procedure which must be planned for the individual, rather than done arbitrarily. The precision we are striving to attain in our final impression is not possible if the baseplate trays fail to meet the necessary requirements (Fig. 2).

The upper primary cast is outlined with pencil from tuberosity to tuberosity to the line where an outward reflection of the cheek begins. The posterior border must be properly placed as regards what is correct for the area of our post dam, which again must be exact for the individual instead of being an arbitrary line. The post dam should be outlined with indelible pencil in the mouth of the patient, so its transfer to the finished impression is possible with absolute accuracy. The post dam, properly placed, will be on the displaceable but unmoving portion of the soft palate. I find it more accurate to establish the post dam by scraping the working cast than by any other method yet devised for use in the actual process of impression making. As a rule, a line connecting the hamular notches on either side will pass through the fovea palatinae, which are the openings of the ducts of a number of palatal glands. They serve as diagnostic landmarks, and indicate the approximate posterior limit of the hard palate (Fig. 3).

The primary cast of the lower jaw is outlined in just as meticulous a manner as is the upper, being ever mindful of the physiologic tolerance and the necessity of anatomic harmony of the structures involved.

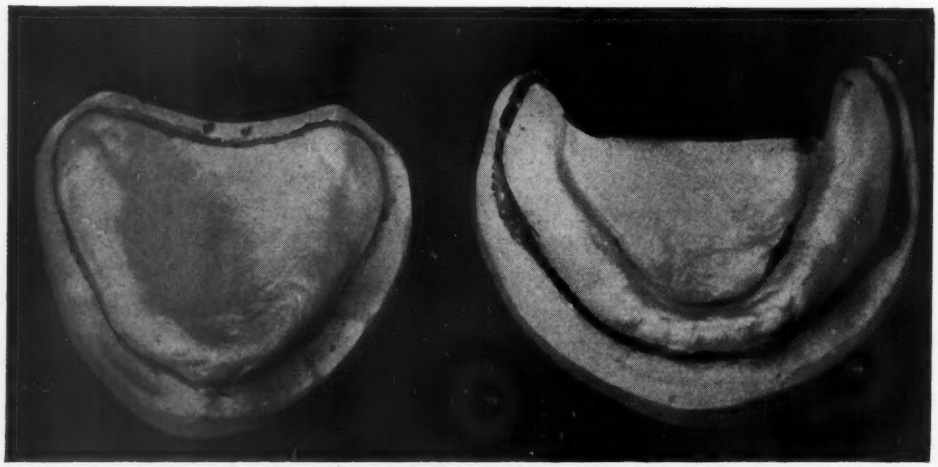

Fig. 2.—Primary casts outlined prior to the adaptation of double-thick baseplate trays.

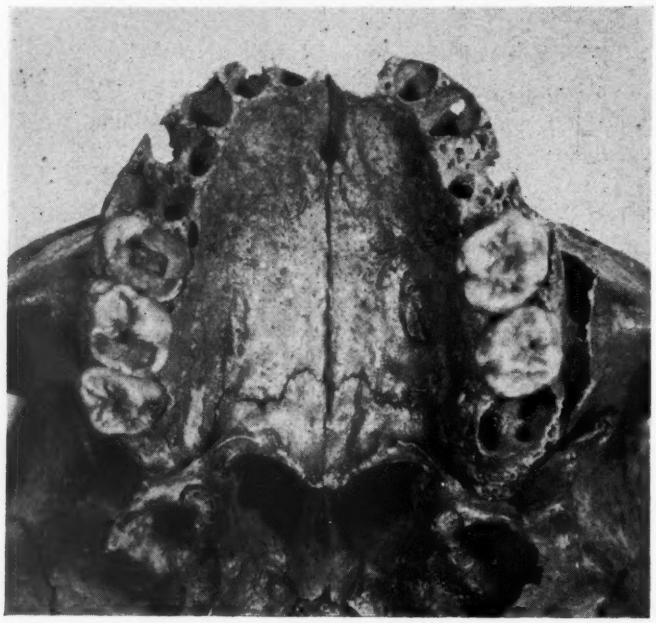

Fig. 3.—Palatal view of a skull showing areas of anatomic significance in upper denture construction.

Beginning the outline on the buccal, the line follows forward along the external oblique ridge of the mandible and joins the lateral surface of the mandible in the region of the bicuspids, with care being taken to make ample clearance for both buccal and labial frenula. This outline continues to the distal, crossing the distal of the retromolar pad, and continuing lingually along

the mylohyoid ridge. It is along this line that an extension of the lower peripheral border should be projected about 2 to 3 mm. below the line of the intended peripheral seal. The flare of the mylohyoid ridge is a lingual one, and this extension toward the floor of the mouth along this line is in harmony with the mandibular anatomy (Fig. 4). I am of the opinion that overextension at this point in no way adds to the retention of the lower denture, but it greatly lends itself to stabilization against lateral stresses. As the outline continues forward, clearance must be made for the lingual frenum. The outline continues on the opposite side along the course just described, until it makes a distal crossing of the retromolar pad area and connects with the buccal outline.

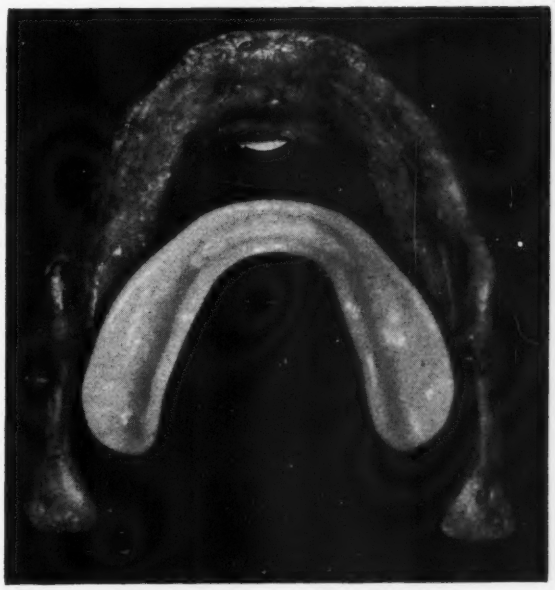

Fig. 4.—Inferior view of a mandible. The harmony of anatomic outline of a typical lower denture is clearly evident.

In the lingual outline, proper attention must be given to the importance of correctly dealing with the mylohyoid muscle. This muscle is often referred to as "the floor of the mouth." With the tongue in an elevated position, the sublingual folds produced by the sublingual glands which lie between the mylohyoid muscles and the mucosa can be seen on either side of the frenum. The extent of these glands must be given consideration in the placing of the lingual peripheral border of the lower denture. We realize that in the act of deglutition these glands are raised, and we know that an impression made of the floor of the mouth when it is relaxed will differ from one made under function. We must also make proper allowance for the tongue movement.

TRAYS FOR FINAL IMPRESSIONS

A shim is formed on the primary casts outlined in the preceding description. A square of wet steamfitter's asbestos is adapted to the primary cast by simple manipulation of the wet asbestos (Fig. 5). This can be done in a matter of seconds. The purpose of shim is to develop a uniform space for our final im-

pression material. We build our tray of double-thick baseplate material over the shim (Fig. 6).

Prior to a description of the method used for securing our final impressions, I think it is pertinent to consider, briefly, the following related facts.

Those advocates of the use of a positive pressure in impression making seem to have as a basis for their procedure the idea that the tighter a denture fits the ridge, the more satisfactory the prosthesis. It is my contention that such reasoning ignores the physiologic tolerance of the tissues involved. Information, that to me is entirely satisfactorily proved, indicates that the average masticatory force is capable of exerting a pressure almost double that of the blood, at its highest possible level. The tissues commonly referred to as noncompressible

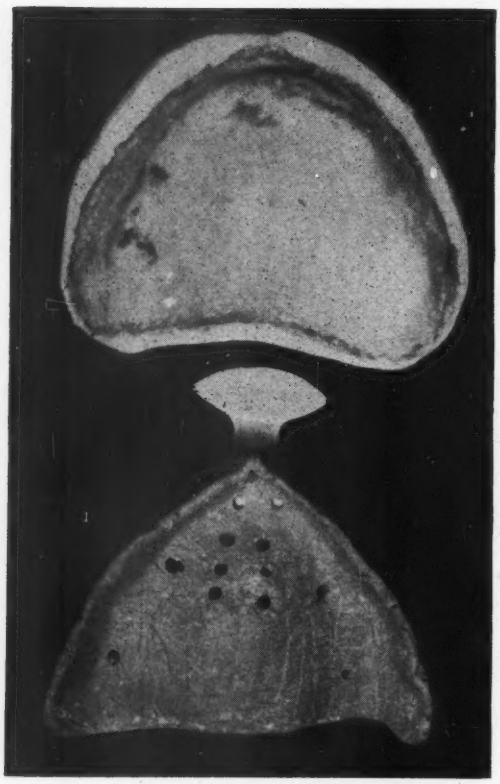

Fig. 5.

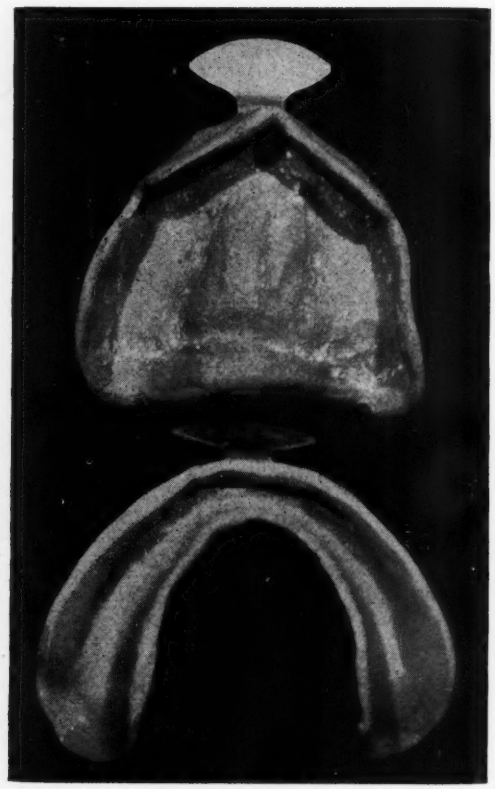

Fig. 6.

Fig. 5.—A shim of steamfitter's asbestos is adapted to the primary cast over which the tray for securing the final impression is made.

Fig. 6.—Upper and lower baseplate trays.

are actually displaceable, in that blood in the tissues being forced back by the greater pressure render these tissues transitorily anemic.

Physiologically and mechanically, the negative pressure principle will more nearly meet the ultimate requirements of an impression than the positive pressure principle. Dentures built according to either principle are reasonably successful but, again, no one impression technique meets the requirements of every case.

Resorption may be due to pressure, disuse atrophy, senescence, or systemic disturbances, either alone or in combination. With insertion of a denture made by the positive pressure technique, pressure is immediately exerted on the tissues in the same amount as that used in recording the tissue position. Any amount of shrinkage serves only to increase this pressure. This continuous pressure precipitates a rapidity of tissue resorption that does not diminish until an equilibrium is established that satisfies tissue physiology. It is not possible to maintain stability of dentures constructed with utter disregard of pressure equalization.

IMPRESSIONS FOR WORKING CASTS

The final impressions are made in a prepared plaster. Plastogum or Truplastic is my choice, although there are others that, when handled properly, will give equally pleasing results. The prepared plaster is mixed according to the manufacturer's directions, and carried to the mouth in the double-thick baseplate tray. The desired impression is thus obtained in plaster under a pressure that may be described as "zero." By use of this method, a precision impression is the product of our efforts. This procedure has incorporated the principle of utilization of maximum pressure-bearing areas and, by use of a loose tray and plaster of proper consistency, has secured a mucostatic peripheral seal that records tissue placement rather than displacement from overdisplacement (Fig. 7).

I am certain that an equally good impression can be obtained with other materials, but plaster is easy to manipulate, will not distort when set, and does the job, whereas other more complicated impression materials have often failed.

Fig. 7.—A final upper plaster impression, and a finished lower denture. Note the peripheral outline.

POURING WORKING CASTS

A good mix of the artificial stone for casts is very important. The mixing is done according to the manufacturer's directions, and the mixture should be placed under a vacuum for the removal of air. The thick mix of stone is machine-vibrated into the impression. Care must be taken to preserve the peripheral border of the impression with absolute accuracy. One-half of a set of metal split cast plates, used for remounting after the dentures are processed, is fixed in the casts during the setting of the stone (Fig. 8). The other one-half of the set of metal split cast plates is used later for attaching the casts to the articulator.

If the metal split cast plates are not used, the bases of the casts should be grooved before mounting. This permits the casts to be removed from the articulator, and replaced on it after the dentures are cured, for the correction of occlusal imbalance that invariably occurs as the result of processing errors.

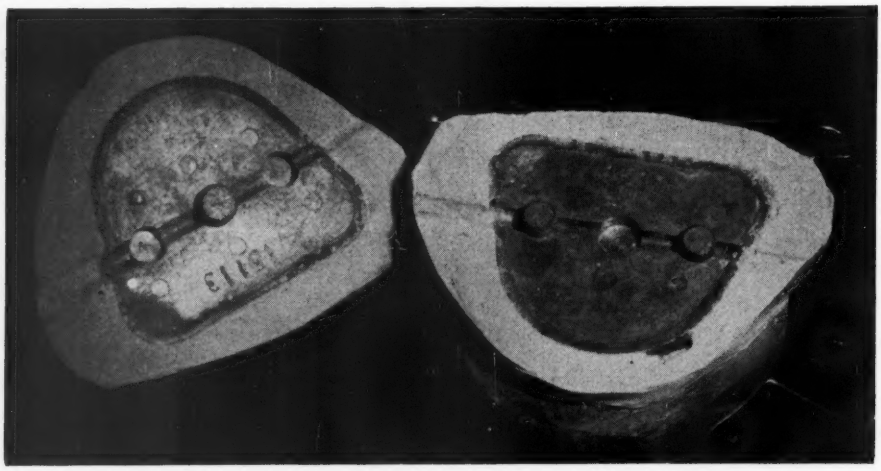

Fig. 8.—Metal split cast plates for reattaching the casts to the articulator after processing.

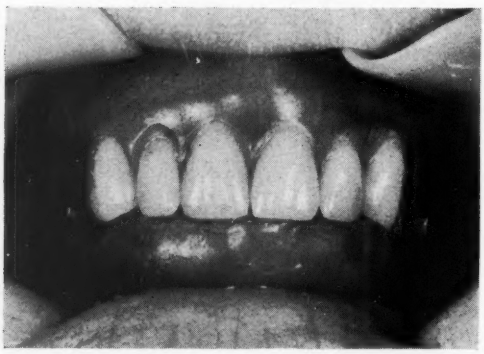

Fig. 9.—Six anterior teeth arranged on the upper occlusion rim.

REGISTERING THE VERTICAL DIMENSION

The term "registering or recording centric relation" when referring to jaw relationship has never had the clarity of meaning as is expressed by the term "registering the vertical dimension." This is a two-phase step, the first part of which is building maxillary and mandibular occlusion rims in wax or modeling compound, on trial bases. These occlusion rims are then adjusted to the free-way space. Our definition of the free-way space is, "The interval between the upper and lower teeth when the mandible is in the physiologic rest position." After the height of the occlusion rims is judged to be correct, a closure to centric relation is accurately established. Our definition of centric relation is, "The relation existing between the maxilla and mandible when the condyle heads are in their most comfortably retruded position in the glenoid fossae from which lateral movements can be made."

Usually the closure from the established height of the occlusion rims to centric relation is approximately 3 mm. This means that the free-way space is approximately 3 mm.

At this point, we arrange the six upper anterior teeth in the occlusion rim (same visit) for trial in the patient's mouth (Fig. 9). We should be striving to build dentures that look well, that are a phonetic aid, and are capable of adequate function.

It is during the establishment of the vertical dimension that a great percentage of the technical errors requiring denture make-overs occurs. I consider the so-called "mush bite" a guess as to its correct location. It is just about as unsound a procedure as being totally ignorant of the existence of vertical dimension and centric relation.

TEETH ARRANGED FOR TRIAL

After the teeth are set up and checked in the mouth for vertical dimension (Fig. 10), wax check bites are obtained to check the mounting on the articulator to verify the accuracy of the original centric relation record. If any inaccuracy is evident, either the upper or lower cast must be remounted. The method used, one for which I shall be ever grateful to Dr. Clyde H. Schuyler, is as follows:

A double thickness of baseplate wax is carefully warmed to a uniform depth. With the upper trial denture already in position in the mouth, the lower denture is inserted, and the patient is asked to close gently into the wax. An even penetration of the cusps into the wax is the required record. It is often necessary to make several impressions in the wax before a satisfactory master record is obtained.

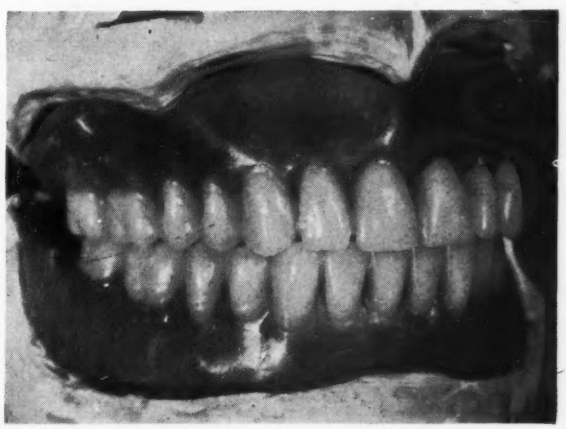

Fig. 10.—Teeth related for trial in the patient's mouth in wax.

Schuyler's statement on this subject is as follows: "Cusp penetration of approximately 1 mm. is most desirable. The thickness of wax separating the teeth should not exceed 1 or 2 mm. The check record is thoroughly chilled and returned to the articulating instrument. Accuracy of mounting is proved only when upon closing the instrument to centric, every tooth cusp fits perfectly into the opposing wax record. [Fig. 11.]

"The value of this procedure in checking the mounting of casts upon an articulating instrument has been confirmed not only in my private practice, over a period of twenty years, but in checking several thousand cases each year at the New York University School of Dentistry. Accurately fitting base trays are essential in obtaining centric relation records regardless of the procedure."[2]

CURING THE DENTURES

In curing dentures, it is always wise to follow the directions for the specific material one is using. However, regardless of the method used in curing, it is generally agreed that the flask should set for at least one hour after it is closed and before the curing process is begun. This procedure lessens the likelihood of porosity.

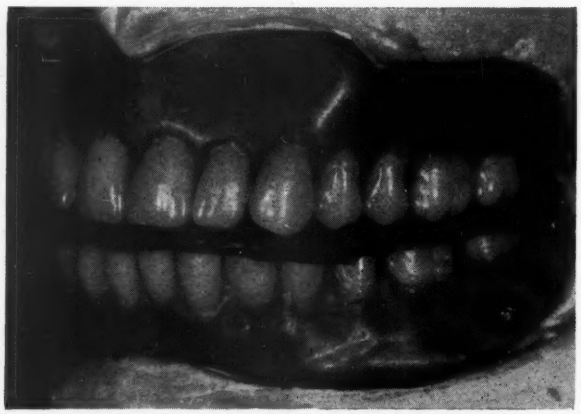

Fig. 11.—The check for the accuracy of the mounting on the articulator.

REMOUNTING FOR CORRECTION OF OCCLUSAL DISHARMONY

I have observed that there is more movement of the upper second molars than of any other teeth during the curing process. This is explained by the fact that tooth movement is the result of acrylic dimensional change during the processing. The span across the denture is widest between the upper second molars. Consequently, the material posterior to these teeth furnishes a greater bulk wherein this greater change occurs (Fig. 12). By curing the upper denture first, and remounting it for correction against the lower denture while it is still waxed, the need for spot grinding is considerably lessened. When the lower denture is cured, it is carried back to the articulator where it is again checked against the upper denture, and any necessary correction is made (Fig. 13).

Seven major objectives in the correction of occlusal disharmony, as described by Schuyler,[3] are as follows:

"1. The maximum distribution of stress in centric maxillomandibular relation.

2. The retention of the maxillomandibular opening.

3. The harmony of guiding inclines, thereby distributing eccentric occlusal stresses.

4. The reduction of the inclines of guiding tooth surfaces, so that occlusal stresses may be more favorably applied to the supporting tissues.
5. The retention of sharpness of cutting cusps.
6. The increase of food exits.
7. The decrease of contact surfaces."

Fig. 12.—The processed dentures returned to the articulating instrument. Note the occlusal imbalance that developed during the processing.

Fig. 13.—The processed upper denture is checked against the lower trial denture while it is still in wax. Correction can be made by readjusting the lower teeth.

It is also interesting to note a statement on this subject by Terrell,[4] "When the cases are remounted on the articulator, it will usually be found that the bite is open from 0.5 to 1 mm. By use of the injection method, or by use of spring

clamps, this change can be kept to a minimum, and a few will come out demonstrating practically no change.

"A small amount of opening does no harm; in fact, it is an advantage as it allows us to do the occlusal correcting and milling, and still complete the case at the original vertical opening."

To those who contend that correction should be done while using the mouth as an articulator, I think that Swenson's[5] observation concerning this debated procedure is worthy of consideration. Swenson said, "The mouth does not afford visibility to properly position and examine the teeth; the resiliency of the tissue precludes constant equalization of pressure in various denture positions; the denture bases shift under incline plane stress without the operators being aware of it, whereas on a stone cast, this cannot happen; the temporomandibular joint can be malpositioned since no repeated checks are possible; and lastly, an exact centric can be obtained and transferred to the articulator which assures an exact and correct starting point for each movement. This correct starting point in the mouth is not controllable."

TOOTH SELECTION

Tooth selection calls for the fitting of the proper type teeth to an individual and to an individual technique. It can become a problem and cause much controversy when it involves the choosing between anatomic and nonanatomic teeth.

The procedure I follow in making dentures lends itself more favorably to the use of the anatomic tooth which is modified to fit my concept of what is required of a tooth.

My reasoning is not in accord with those who contend that anatomic tooth forms are prone to reduce denture stability. Some say this is true because of the progressive, so-called settling of dentures due to alveolar loss. A reduction of denture stability would be brought about only when the anatomic teeth are arranged with too steep an incisal guidance. Therefore, my contention is that denture stability is in no way impaired when the anatomic teeth are modified and balanced with the same favorable incisal guidance as are cuspless teeth.

I think the problem of alveolar resorption becomes more difficult when cuspless teeth are used in dentures. This is explained by the tooth's tendency to develop premature contacts on the last molars. These contacts are liable to result in the loss of vertical dimension, when one is employing a technique and a tooth that is almost solely dependent upon a fixed arbitrary compensating curve for maintenance of balance, rather than the cuspal inclines of each tooth.

After giving much thought and consideration to the actual functions of a tooth, I have concluded that one with very sharp cutting blades has the greatest advantages. During the process of mastication, and when the jaws are free of the controlling action of tooth cusps, the mandible makes a universal excursion, returning on varying axes until the teeth come together again. It is not likely that one effects an exact centric relation in the cycle of mastication until the morsel of food has become completely masticated and ready to be swallowed. Therefore, it is logical that teeth with sharp cutting blades would serve their purpose better than teeth more dependent upon maceration.

However, the tooth selected should have the qualities to masticate efficiently, with resultant tissue trauma diminishing in proportion with the amount of biting pressure exerted.

I am awaiting, with interest, the opportunity of using some of the Hardy[8] "metal insert teeth." He said, "Nature can easily apply a hundred pounds of biting pressure on natural teeth. Tests made with a newly designed and extremely sensitive electrognathodynometer, developed at Tufts College, show that few patients wearing artificial teeth can develop 30 pounds of biting pressure, and many develop only 5 pounds, the average being 15 pounds, or thereabouts. The denture wearer is under the handicap of being able to apply only greatly diminished biting force."

SELECTIVE GRINDING

When the cured dentures are taken from the flasks, and before they are removed from the casts they are reattached to the articulator through the use of the metal split cast plates. If grooving has been used, they may be secured with plaster. We next check for points of cuspal interference by use of typewriter carbon paper. When they are discovered, we reduce these points until our incisal pin guide indicates the required correction has been made. By selective spot-grinding in lateral and protrusive positions, we continue correction until the dentures have freedom of movement in all positions, and have no cuspal interference. We use small stones for grinding. After the teeth are polished, the dentures are removed from the casts and made ready for delivery to the patient. In most instances where the procedure described is followed with complete accuracy, there is no need for further adjustment in the mouth (Fig. 14).

Fig. 14.—Dentures ready for delivery to the patient.

FOLLOW-UP

The patient returns the day after receiving the dentures for a check on the need for any minor adjustment that may have become necessary. During this visit, another appointment is made for a return visit in one week. This is for

the purpose of securing a centric relation wax record from the mouth for the purpose of making the final occlusal equilibration (Fig. 15).

In outlining my procedure in denture making, I have refrained from giving any set rules regarding the mechanics. However, there are fundamental considerations which should receive the proper attention. Fundamentals never change. I am convinced that anatomic structures are so variable that there is no logic in trying to reduce theories concerning them to the exactitudes of geometrics. Each case must be planned and suited to an individual. Being ever mindful of this fact helps me keep my "prosthetic thinking" in line.

American dentistry is to be complimented on its skill in making dentures so well that they enable the wearer to improve his appearance and to masticate effectively. Even so, I think, we are on the threshold of being able to render a much better denture service than has yet been realized.

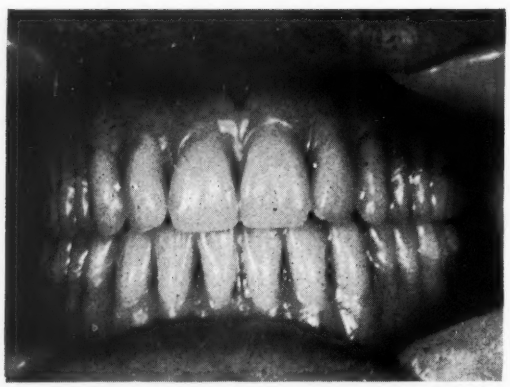

Fig. 15.—Dentures in the mouth of the patient, after the final occlusal equilibration.

It should be kept foremost in our minds that, as prosthetists, we are placed in the position of rendering a health service not exceeded in importance by the services rendered by any other specialty of either medicine or dentistry. To render this service efficiently we must couple with our technical knowledge a complete understanding of psychology, physiology, histology, and anatomy. In fact, we are required to combine information of all the basic sciences with a generous measure of common sense.

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RAPID POLYMERIZATION AND CEMENTATION IN DENTURE CONSTRUCTION

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FEW MATERIALS for dental use have attracted so much interest among the members of the dental profession as the introduction of cold, rapid solidifying plastic products. Manufacturers and distributers, through their advertisements, have pictured the outstanding properties of these improved resinous compounds, drawing attention to their wide application and the simplicity of manipulation. This publicity, followed by restorative experimental service, has been far reaching, and there appears to be a decided difference in opinion as to whether the advertised claims can be substantiated. This article is designed to present an entirely different concept of what takes place during the period of polymerization and to furnish some data on research and clinical observation as applied to the prosthetic field, but it should be understood that the chemical and physical properties of these rapid polymerizing resins have a basic relationship, regardless of where they are used.

"HOT" AND "COLD" POLYMERIZATION

The practical application of this type of material to the construction of a denture base is relatively new, and yet there is very little difference in the chemical and physical composition between the new "cold" resin compound and standard "hot" acrylic materials. In the comment and analysis to follow, these two terms, "hot" and "cold," will be used for the purpose of simplicity. It is fairly well understood by dentists that rapid or cold polymerizing preparations contain an activating catalyst which causes a quick heat reaction when the monomer and polymer are mixed together, which results in solidification of the material. As a rule, only a small amount of the catalyst in combination with some accelerating agent such as an amine, metalic, nonmetalic acid, or alkaline is used. The size and shape of the polymer contributes much to the speed and hardening of the material.

A study of the chemical action which takes place during the processing of an appliance, where cold self-curing products are used, discloses that the speeding up of polymerization by internal chemical heat actually interferes with the normal long-chain molecular formation. This disturbance in the chemical equilibrium, complicated by condensing pressure from closing of the flask, accounts

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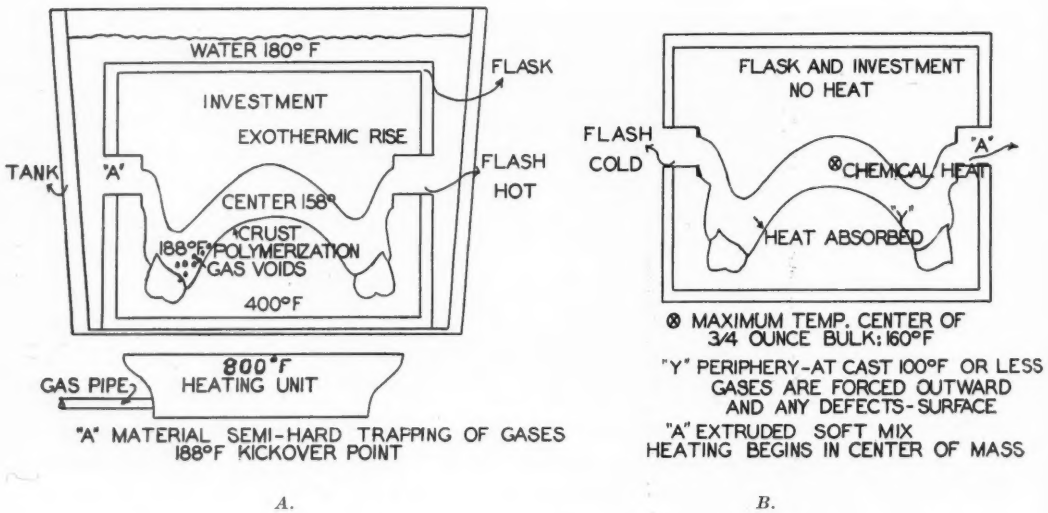
for the presence of some fugitive free monomer and excess gases which are forced out with the extruded "flash" from the base material. No attempt will be made in this text to delve into the finer chemical ramifications of the acrylic in denture processing, but some effort will be made to present an entirely different concept of what takes place during the period of polymerization. Before undertaking to point out any specific factor allied with rapid polymerization, a brief comparative study will be presented on the behavior of hot and cold materials during processing.

Under the technique used today for the solidification of acrylic base materials, there is an accepted belief that heat must be present for the hardening reaction. If complete polymerization were necessary for success in denture construction, it is very questionable if the average laboratory technician could, or would, comply with this high and questionable standard.



A. *B.*

Fig. 1.—Comparative study of hot and cold processing of acrylic denture base material. *A*, Hot material. External heating. *B*, Cold material. Internal heating.

Denture construction is done by the relatively slow, carefully controlled heat and pressure technique. The processing involves the use of externally applied heat which is conveyed through a series of absorbing interferences, namely, a metal tank, water, and investment before it reaches the "mix." The new method of cold processing presents quite a contrast to this technique (Fig. 1). There is a complete reversal of the heating system, as the chemical heat originates in the center of the plastic mix, and the heat travels outward. As a rule, polymerization begins at the point of greatest heat, and whenever oxidizing catalysts or accelerators are present in the bulk material, the solidifying action will be accentuated. During this phenomenon of polymerization, if the mass is undisturbed, a systematic long molecular chain reaction will result. However, an excessive amount of heat, either from external sources or internally created, will often result in imperfections in the finished appliance.

INTERNAL VS. EXTERNAL HEAT

From the foregoing analysis of the effect of heat, it should be apparent that with the standard hot material, the processing in a flask will undergo solidification about the periphery and between the halves of the mold *first*. This initial stiffening formation of a semipolymerized sack or crust results in a complete incasement of the base mix, before the mass reaches a polymerization balance. This explains to some extent why void spaces in bulky dentures are often present. These so-called "air bubbles" are actually vacuum spaces. If a vacuum is created early in the plastic mix, due to heat and quick absorption of the monomer by the polymer particles, not only will void spaces be created but the internal tension upon cooling causes contraction which will draw the material away from the cast.

Polymerization of the cold materials starts in the center of the mass, and the gases, with some of the liquid in the mix, are forced or filtered outward. Defects, if any, will be noted on the outside of the appliance, but the material will always remain in close contact with the cast. Aside from the practical application of these cold testing experiments, considerable laboratory research work was done to determine if this chemical heat reaction could be regulated or controlled.

THERMODYNAMIC STUDY OF THERMOPLASTICS

This thermodynamic study of thermoplastics has indicated clearly that: (1) Chemically created heat, and the dissipation of such heat, depends to a major extent on the processing methods used, in particular "the heat absorbed by the system." (2) This chemical reaction is rather chaotic and to some extent spontaneous. During polymerization, there is a considerable loss of the solvent radical by evaporation which causes condensing and extruding forces. These factors tend to place the mixture in an unbalanced state of equilibrium.

From many experimental tests, it is quite obvious that there is a decided difference in the time and amount of heat generated in a mix under slight pressure and exposed to air as compared to a mix which is confined in a mold under high pressure. As an illustration, a 30-gram mix of cold material was divided into two portions, one-half of the mix was held in the hand with a thermometer in center of the mass, and another thermometer placed between the closed fist and the mix. A confusing temperature recording resulted from this experiment. First, there was a primary rise in temperature at the surface of the mix. The thermometer reading next to the palm reached 150° F. in six minutes, and at the same time the thermometer at the center of the mass indicated 142° F. This primary action was quickly followed by an intense internal temperature rise. The temperature of the center of the mass reached 210° F. in twelve minutes, while the surface recording was 180° F. As an explanation, it is presumed that the cold mix contacting the palm of the hand at the body heat of 98° F. acted as a "priming" agent for the chemical action that followed.

The other one-half of the same mix was confined within a mold under pressure. An entirely different temperature registration was discovered (Fig. 2). This astonishing disclosure, showing the apparent absence of heat at the periphery during the confined pressure molding procedure and the fact that the mix becomes solidified in twenty minutes, is of particular interest. In order to confirm this absence of peripheral heat (below 90° F.), a Kerr's baseplate wax disk, 2½ × ⅜ in., was made with metal coin impressions imprinted on the flat surface. The wax disk was placed in the metal mold, and a mix of the cold material was prepared and forced into position against this wax disk under a pressure of 800 psi. The plastic was processed and removed in twenty

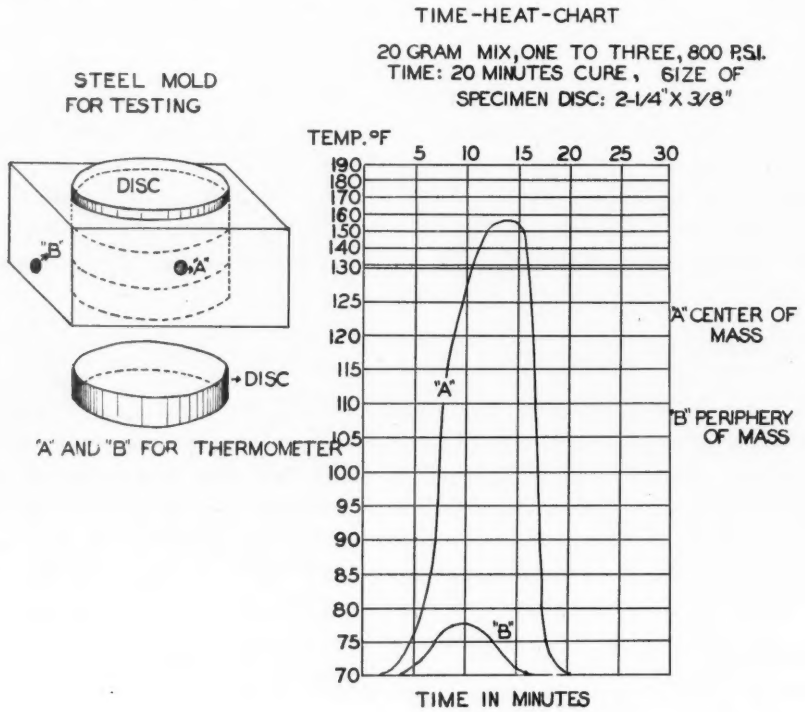


Fig. 2.—Cold processing. Approximate reaction (questionable methods of preparing and processing will affect monomer evaporation, heat absorption, material flow, and cementation, resulting in considerable differences in the values indicated on the chart). Time-temperature chart for cold materials.

minutes (Fig. 3). These photographs of the wax disk mold, and the resulting plastic specimen, demonstrate clearly that the wax was neither melted, nor the form altered, by the pressure used in closing the flask. The problem of thermodynamic control is thus more complicated than that which occurs in the open-air reactions of material when held in the hand.

CEMENTATION

In explanation of this semicold processing, attention is called to the word "Cementation" as it appears in the title of this paper and to the preliminary

statement, " . . . to present an entirely different concept of what takes place during the period of polymerization . . . . " "Cementation" is sufficient to convey the thought that plastic particles can be cemented together under pressure without heat. To substantiate this thought, opaque and clear acrylic beads may be cemented together under pressure with ordinary methyl methacrylate monomer, whose solvent properties act as a cementing medium. Polymerization is recognized as a chemical reaction, while the cementing together of plastic solids by the use of some solvent has been looked upon as a physical union. Regardless of what occurs in either case, it is reasonable to assume that a successful bonding can be accomplished by combining the two reactions.

A. *B.*

Fig. 3.—*A*, Wax molds. *B*, Resulting plastic specimen which was processed against wax in twenty minutes under 800 pounds' pressure.

It should be mentioned that small partially dissolved particles which are cemented together during rapid polymerization may be regarded as "fillers." In the field of operative dentistry, a lamination technique is used *without pressure* for fillings. There is considerable difference in the physical structure of the small acrylic restoration and the large denture base. The general rule is: where a chemical action is limited to a short period of time, a bulk of material requires pressure to obtain density.

The following conclusions have been arrived at from a series of laboratory experiments and from careful consideration of the preparing and processing of prosthetic appliances:

1. It is possible to cement together polymer particles or acrylic strips under pressure with regular methyl methacrylate monomer (not activated) as the cementing media, without the application of heat (Figs. 4 and 5).

2. It is possible to bond together acrylic beads and polymer particles by polymerization and cementation with an activated monomer under pressure and still retain the identity of the composition (Fig. 6).

3. Fine polymer particles may be incorporated in an activated monomer to form a paint or paste that may be applied to the root areas of the plastic teeth; this will form a bonding coat which will act as a cementing union with the denture base mix. The small partially dissolved particles cemented together during rapid polymerization period are to be regarded as "fillers."

4. It is possible to force or filter out a certain amount of the liquid (free monomer) and gases from a cold mix, which assists in the control of the amount of heat generated.

5. The elimination of external heat in a cold mix results in the rapid dissipation of the internal chemical heat in the surrounding walls of the investment. This is impossible with a hot material.

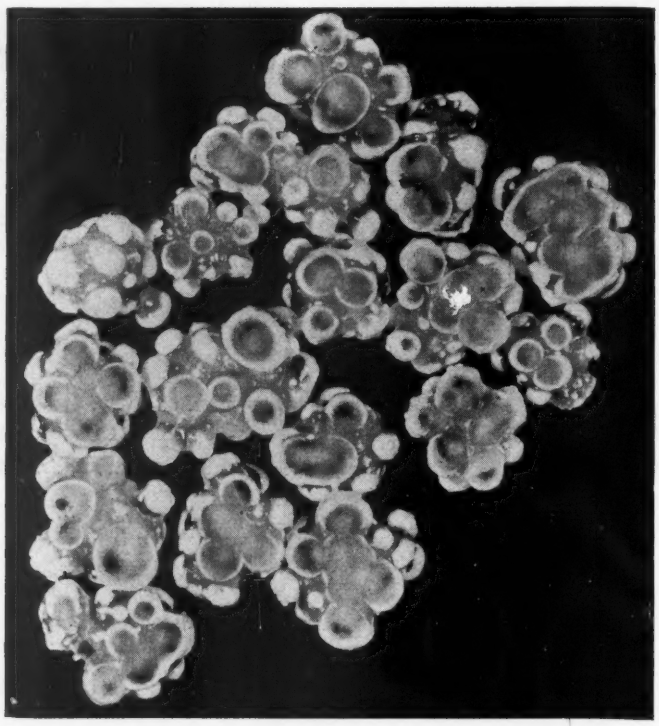
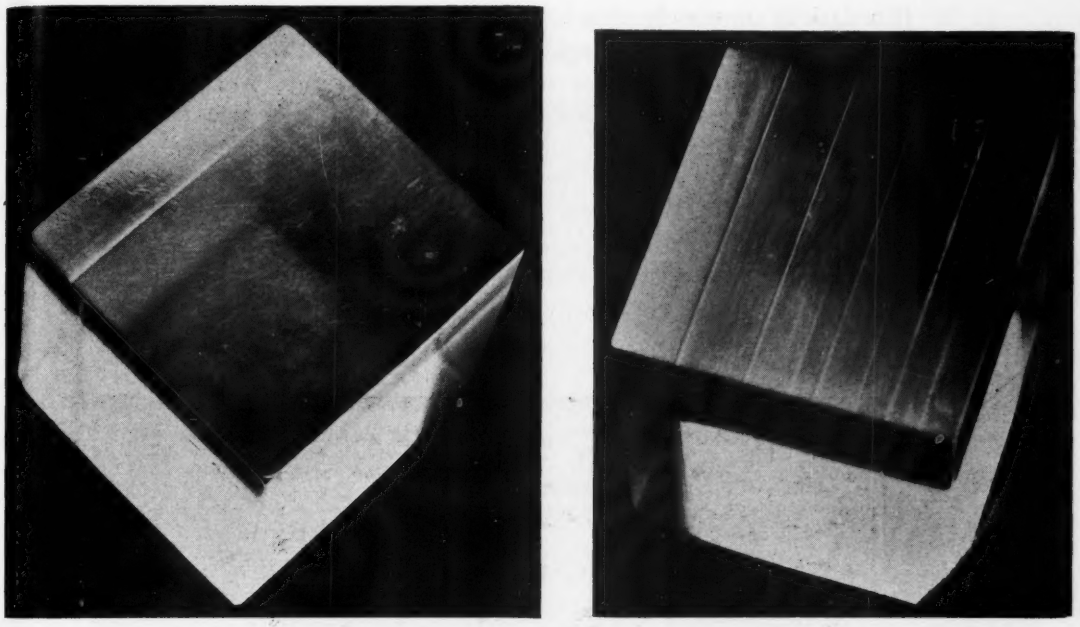


Fig. 4.—Opaque and clear beads cemented together under pressure without heat using a regular monomer (enlarged).

6. Cold material, in a flask under cementing pressure and during polymerization, may be solidified *without* an equal distribution of heat throughout the mix.

7. Polymerization originating in the center of the cold mass, during the processing, will continue after the semisolid specimen is removed from the flask, with little perceptible change in form.

8. Polymerization (a chemical reaction), when once set in motion, will continue until solidification is complete. The agents used to speed up the action may be reflected in the physical structure of the processed material.



A. *B.*

Fig. 5.—A crylic strip cemented together (laminated) with a methyl methacrylate monomer without heat, under pressure, to form a clear block specimen. *A*, Top view. *B*, Side view.

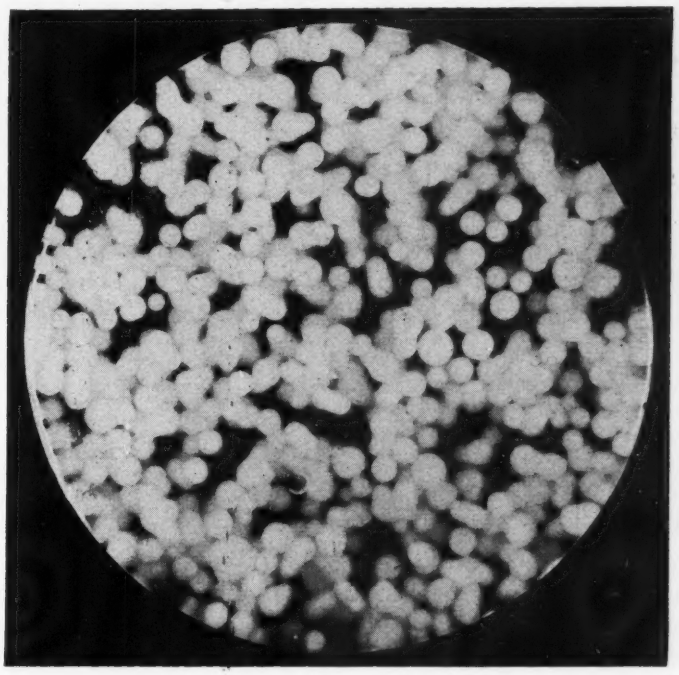


Fig. 6.—Disk of opaque and clear beads polymerized and cemented together with a fast acrylic monomer under a pressure of 5,000 psi. (enlarged).

9. If a flask is completely closed, and the mass of cold material is trapped before the polymerization action begins at the center of the mass, it will be noted thereafter that each degree of rise in the temperature will increase the amount of expanding pressure. Attempts were made to determine the amount of pressure increase, per gram of material, per degree of the rising chemical heat, but the figures were found to be unsatisfactory. However, it is this expanding heat force, which starts in the center of the mass, which drives the soft outer portion of the mix to an accurate relationship within the mold.

From the foregoing, it is apparent that activated, generated heat can be not only reasonably reduced in intensity, but its expanding force may be directed to drive the material to a remarkable cast adaptation.

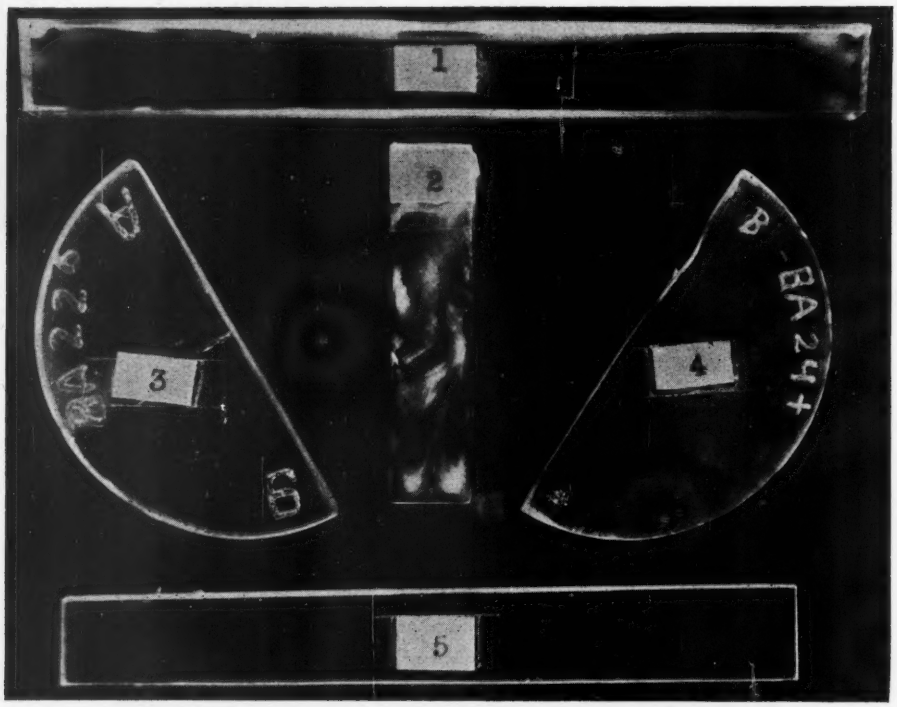


Fig. 7.—Strains in plastic specimens. *1*, Hot rolled. *2*, Injection molded,, 5 tons' pressure. *3*, Disk hot-processed 5,000 psi. *4*, Disk cold-processed 5,000 psi. *5*, Plexiglas, no pressure.

STRAINS

The molding of any thermoplastic article always results in the formation of incorporated strains (Fig. 7). These forces, whether spontaneously or gradually released after the construction of an appliance, are usually serious. The proper scientific method to prevent stresses and strains is to avoid creating them in the processing. A Plexiglas sheet, which is relatively strain free, is made from a monomer which is poured between two plates and permitted to polymerize slowly over a period of time. A polymer which is practically free from these strains can also be made from a monomer by the removal of the generated gases by the use of a vacuum during the curing. Other methods for the control of

the strain problem are accomplished by the incorporation of fillers in the acrylic resin, or by changing the molecular chain arrangement during its processing.

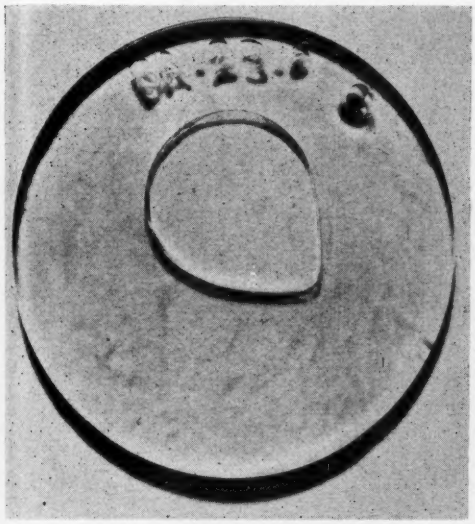


Fig. 8.

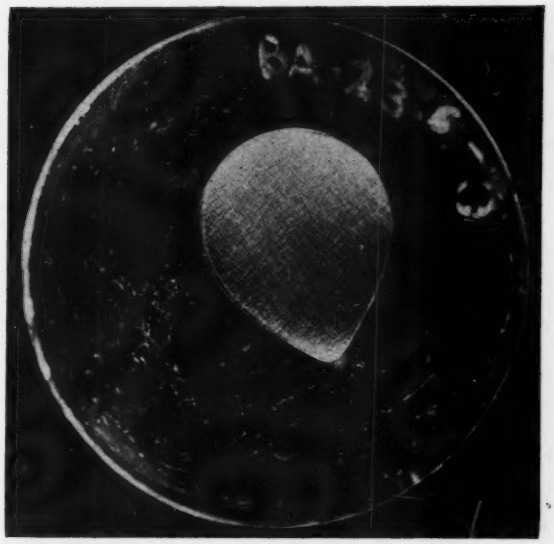


Fig. 9.

Fig. 8.—The heart-shaped center of the disk is of the noncrazing cross-linked plastic used in high heat-resistant plastic teeth under ordinary light.

Fig. 9.—The same specimen under polarized light. The center "basket weave" is formed by the "cross-linking."

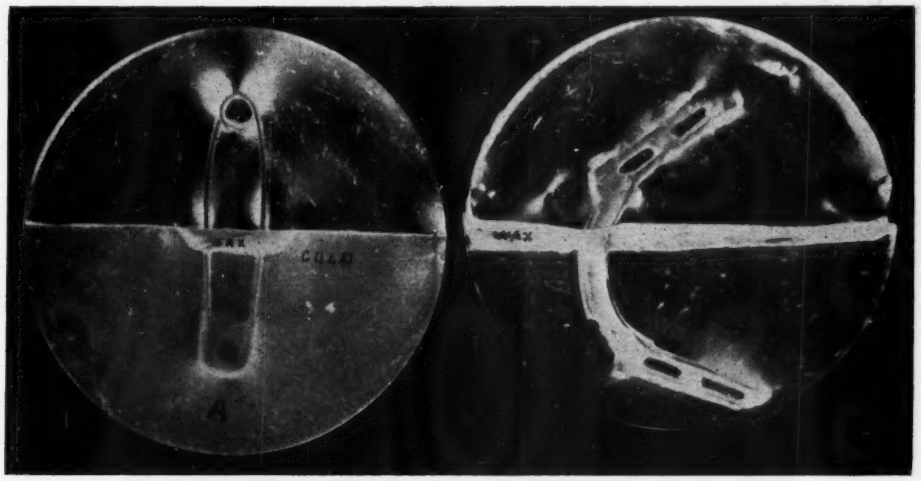


Fig. 10.—Two disks with metal inserts. The upper one-half of both specimens are hot processed, and lower section, cold, 20-minute material. (Polarized light.)

There has been considerable improvement in the manufacturing of copolymers by the development of a cross-link or crystalline "basket weave" molecular formation. This has a high resistance to solvents, and internal forces are held under control. Artificial tooth manufacturers are now able to make strain-free plastic

teeth of copolymers which do not "craze," are extra hard, and have high heat-resistant properties (Figs. 8 and 9).

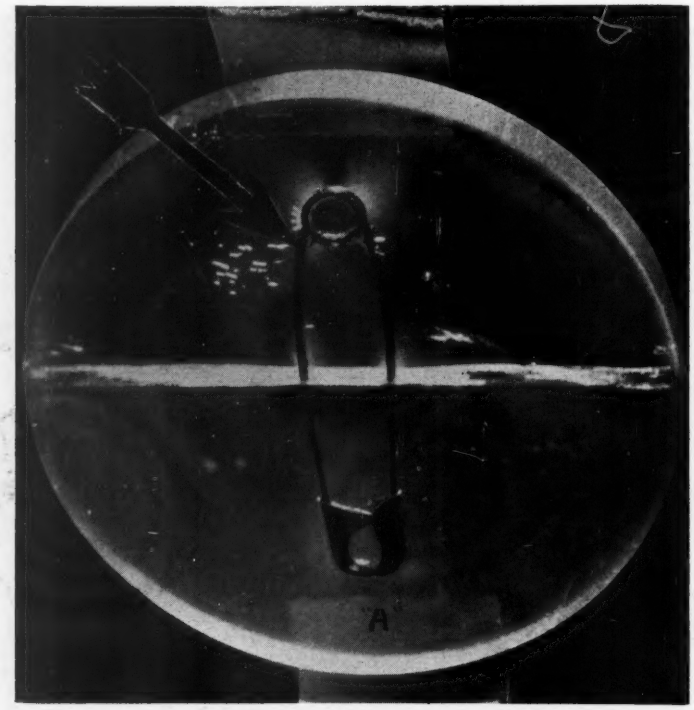


Fig. 11.—This hot-cold specimen with a metal insert was dipped in whiskey for 15 seconds. Note the checks in the upper (hot) one-half, while the lower one-half, *A*, (cold) shows no evidence of the crazing.

Fig. 12.—This four-tooth specimen shows the result of a 10-second dipping in monomer which caused the checking of some plastic teeth.

The major cause for the creation of strains in these base materials is primarily the processing technique or the treatment to which the article is subjected

after construction. The formation of strains in acrylic appliances during processing can be attributed chiefly to heat and pressure. These two factors relate directly to the previous comparative study of hot and cold products. Before leaving the subject of strains, it is well to point out why the creation of these forces should be reduced to a minimum (Fig. 10). This internal tension can be released quickly by many agents, for example, a plastic denture may crack through the palate from contact with an alcohol mouthwash, or a denture will often fracture

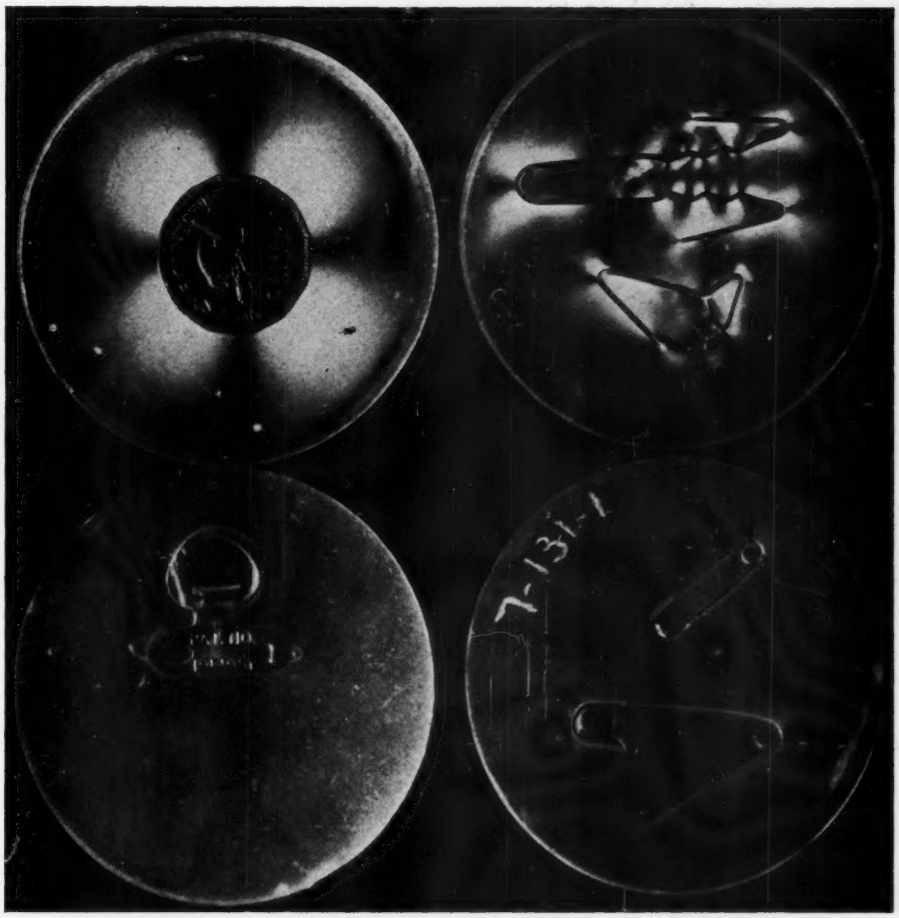
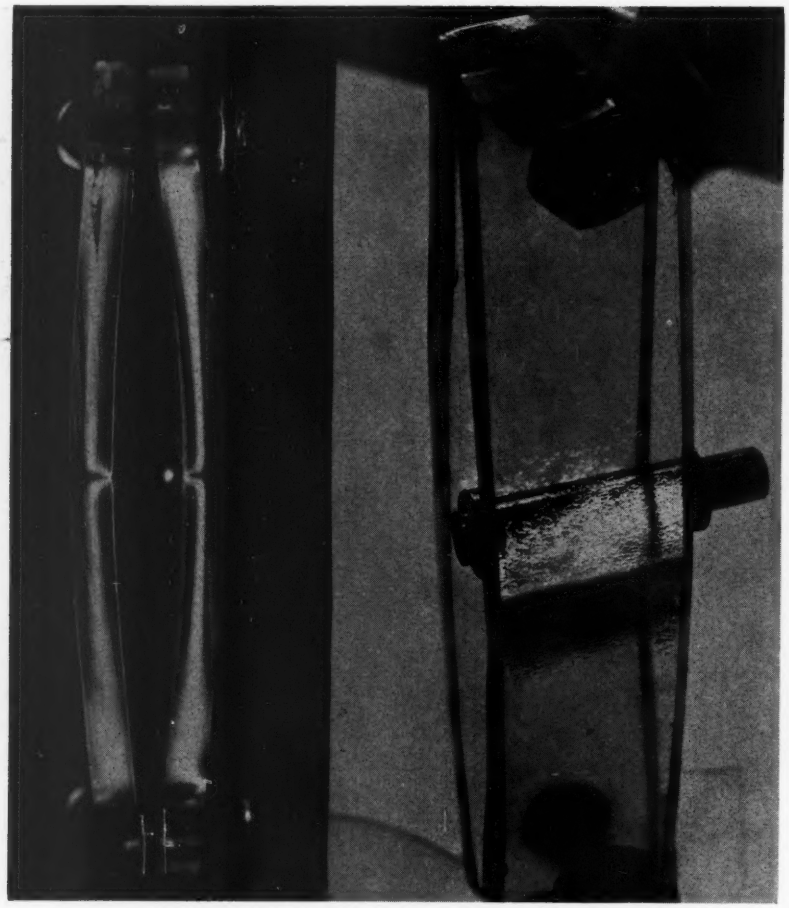


Fig. 13.—All disks with metal inserts were processed under 5,000 psi. Upper disks of hot material; lower disks of cold material. Note the strains in the hot disks and the absence of strains in the cold disks. (Polarized light.)

about metal inserts from contact with a "whiskey sour" (Fig. 11). A denture repair, by means of monomer-polymer mix, may lead to a subsequent series of repairs due to the release of original processing strains. An acrylic tooth in a denture in the absence of controls will instantly craze by the application of a monomer (Fig. 12). This study of specimens under polarized light reveals there is a great difference between hot and cold materials used in denture construction.

Strains in plastic appliances must be considered as physical defects, and there is no difficulty in determining the location of these forces when the clear specimens of both hot and cold materials were prepared and observed under the polarized light. The relative freedom from strains in the cold material as compared with the strain pattern noted in the hot material demonstrates the superiority of the cold material in this respect (Fig. 13). The cold low-heat processed denture presents more cast accuracy and less primary strains than the hot material, but active internal forces may be quickly formed when any finished denture is placed under tension, for example: a denture is liable to fracture by a combination of an applied force and an alcohol mouthwash (Figs. 14, 15, and 16).



A. *B.*

Fig. 14.—*A*, Acrylic strip under tension (polarized light). *B*, Result of an application of alcohol hot processing.

COMPARATIVE ANALYSIS OF HOT AND COLD MATERIAL

As heat is the major cause of strains in plastics, it may be readily understood that cold-processed appliances, with less heat involved in their construction, possess

a greater resistance to solvents and other strain-releasing agents than is possible with hot materials.

The study of many hot and cold disk specimens, molded under 800 psi, under the polarized light show strain patterns in all hot materials, especially where metal inserts were used; on the other hand, the cold samples, as may be observed in the illustrations, are reasonably clear, which indicates they are relatively strain free. For further evidence of the cold-processing specimens being comparatively free from internal forces, numbers of disks of both hot and cold materials were made and immersed in a regular acrylic monomer. The cracking or crazing of the hot specimens, especially those with metal inserts, and the absence of checks in cold material was sufficient to confirm the freedom from strains in the latter material.

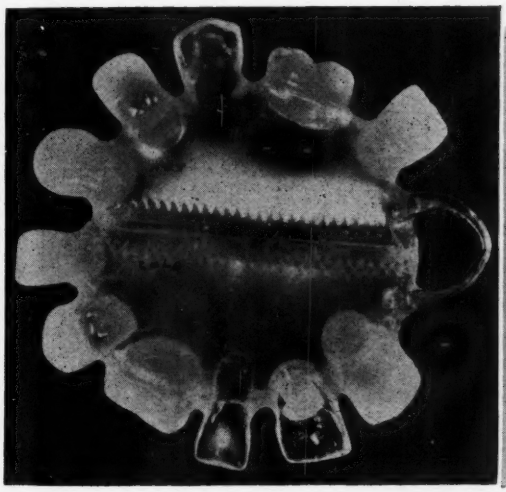


Fig. 15.

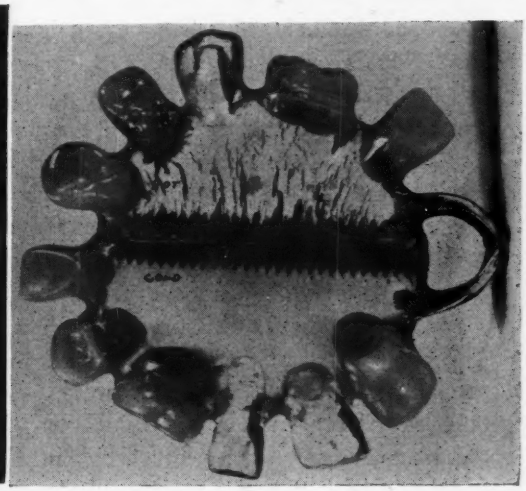


Fig. 16.

Fig. 15.—Disk with a metal bar and an assortment of teeth as it appears under polarized light.

Fig. 16.—The same specimen after being immersed in acrylic monomer for 10 seconds. Note extent of checking of hot material (top) and the teeth affected.

The absence of visable strains in the cold material should not be associated with a primary physical surface softness. The surface softness of the cold material is sometimes but incorrectly referred to as an "undercured" material. There is sufficient evidence, by the use of the periodic Barcol reading, to prove that the hardness of the cold material increases as time passes on. It may be pointed out that a *hot* underprocessed denture worn in the mouth will in a very short time set up a decided irritation; on the other hand, hundreds of cold-processed dentures with slight surface softness were placed in the mouths of patients during a period of over two years without a reported case of monomer inflammation.

TRANSVERSE PHYSICAL PROPERTIES OF COLD MATERIAL

The American Dental Association Specification No. 12, which provides certain rules for the testing of denture base materials, as a requirement for the certification of commercial denture products, was set up years ago. It is reason-

able to presume that this regulation was not intended to cover every future development.

Specimens made up from cold denture base products do not comply with the American Dental Association Specification No. 12, at present, as to "load" and "deflection." Yet, from a comparative analysis, many other physical properties of these cold materials offset the "transverse testing" with the specified apparatus required by the American Dental Association. Certain physical properties are necessary in plastic mouth restorations, but accuracy of fit stands first in clinical service. When cold materials are employed, the prosthodontist is able to construct appliances which fit the tissue more accurately than when hot materials are used.

PHYSICAL CHANGES

Some changes in form will occur in all thermoplastic appliances, but the extent of this deformity from the original pattern depends on many factors.

1. It is almost impossible to completely fill the mold cavity with a mix of acrylic, close the flask while it is slightly warm, process in two hours, and have an accurate contact of the appliance with the cast when the flask is cooled.

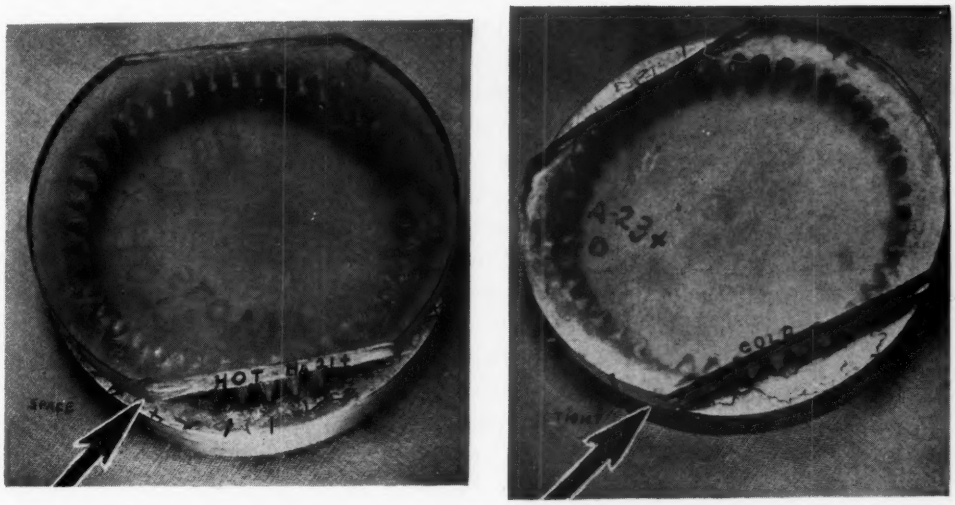
2. If flask pressure is exerted *after* polymerization is started to insure better cast adaptation (use of springs, etc.), elastic deformation will follow later.

3. If great pressure and external heat are applied in hot processing, the resulting structure will be relatively hard and can be highly polished, but the internal strain will in time cause the material to yield to many agents. Often a weak solvent will crack the appliance.

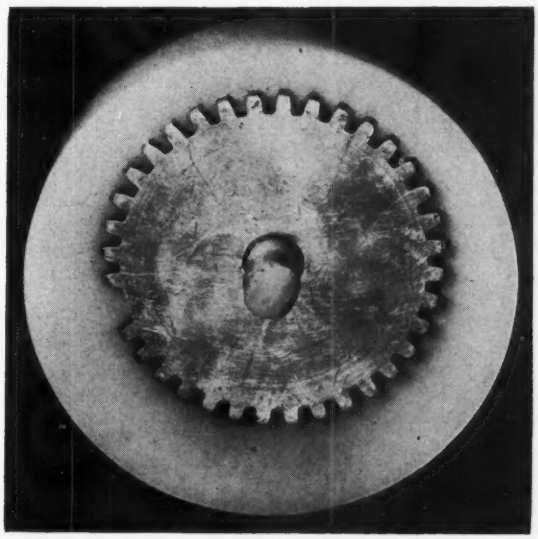
In contrast to the physical changes accompanying the construction of dentures by hot processing, as indicated above, a cold-processed denture will not only record the finest mold details, but the latent physical changes are less than the over-all inaccuracies occurring in the formation of hot-processed dentures (See Fig. 17*A, B,* and *C*). These three disks were all processed in a gear-designed metal mold, under a pressure of 5000 psi. The cold materials, *B* and *C,* were processed and removed from the flasks in twenty minutes, while the hot specimen, *A,* required one hour and forty-five minutes for the curing and cooling. After the speciments were processed, a Baumé reading was obtained by using the prepared magnesium chloride solution and the heavy liquid hydrometer. Testing the density of the hot and cold specimens confirmed many previous experiments. The cold samples were superior in structure to the hot sample as will be noted by the markings appearing on the disks.

The processed gear disks were weighed and placed in a water bath for fifty-six hours. They were weighed again to determine the amount of water absorption. The slight increase in weight was of minor importance, and attention was thereafter centered on the adaptation of the processed pieces to the metal gears. For several weeks, the disks *A* and *B* could be easily adjusted to the inside gear, with an increase in tightness of the disk *A* and possibly a little freedom of fit of disk *B*. In about three months, it was no longer possible to force disk *A* into the gear mold, and this condition still continues. Six months after the disks were made, disk *B* could be seated in the mold, while disk *A* showed some broken gear points, and no longer fitted the mold. Disk *C* made of the cold

material which was molded on the outside of a gear wheel presented a very tight fit, and it could only be removed with some difficulty.*



A. *B.*



C.

Fig. 17.—Plastic gear disks. *A*, Hot material. *B*, Cold material. *C*, Cold Material. Note the fit of the disk.

This study of physical changes in specimens which were formed to fit an internal and external metal gear would seem to indicate that the hot-processed specimen will expand in open air, over a period of time, while the cold specimen

*Two cold outside gear specimens were made during January, 1951, and now after a period of eleven months (December, 1951), they may be seated and removed from the gear without difficulty.

will undergo contraction. This is not correct, as other tests indicate that all molded acrylic pieces will undergo a bulk contraction.

However, the contracting pattern or deformation of the two processed materials is different. This is probably due to the character of the strains present in the processed specimens.

MATERIAL TESTING

It is difficult to set up a definite standard for testing plastic specimens as the physical readings, such as hardness, tensile strength, water absorption, strains, density, et cetera, depend not only on the quality of the material used, but on the methods of preparing and processing. More exacting care is required in handling the cold materials than hot materials. For example, it is common practice for dental laboratories to prepare a large quantity (sufficient for several cases) of the hot material at one time. If this bulk technique was used in preparing the cold materials, serious complications would result. The chemical reaction would quickly solidify the entire mass regardless of refrigeration.

There is often an absence of the details of the preparation of the specimens used for testing in published articles on this subject. It would be impossible to obtain the same results, even with identical materials, if the amount of the material and the proportion of the mix were different. Likewise, a specimen made up by "trapping" a mix under high pressure would certainly present a better physical structure than a sample which was indifferently processed with a bulk of material and only slight pressure.

DENTURE CONSTRUCTION WITH COLD MATERIAL

There is very little actual difference between hot and cold denture products. Manufacturing experiments, coupled with clinical reports, have resulted in marked improvements in the cold material which now threatens the security of the standard hot denture base material. The success in the construction of the dentures from cold materials depends on three principal factors: the equipment, the material, and the technique. Before referring specifically to the three major requirements, the technician is cautioned against the use of poor equipment and materials. Any saving of time can only be accomplished with care and in preparation for the work. The following outline of the requirements and technical procedure is based on the results obtained from a long series of laboratory tests and considerable clinical experience.

EQUIPMENT

The most important instruments for this work are the flask and press, both of which must be well constructed and easy to handle.

The Flask.—A large-sized, flat-type, boltless flask, into which a waxed setup on the cast can be correctly seated, is recommended. The flask must be easy to close and disassemble. The parts should fit with mechanical accuracy and should go into a position without danger of the cold base material interfering with the closing of the device.

Accessories.—Mixing jars, a stainless steel spatula, and a measuring glass are necessary accessories for preparing the material.

The Press.—A heavy, strong, easy-to-operate press, with parallel plates which contact and extend beyond the flat cover of the flask is the most satisfactory. If available, an S. S. White Resovin press (Fig. 18), or one of the later hydraulic presses where the amount of pressure is recorded, is ideal (Fig. 19). If it is necessary to use the more conventional smaller press, it must be firmly attached to the bench for security and leverage. High pressure is absolutely necessary, *not* because of any difficulty in making the "mix" flow, but because the "batch" in the flask is trapped, and the excess material can only be extruded by considerable pressure.

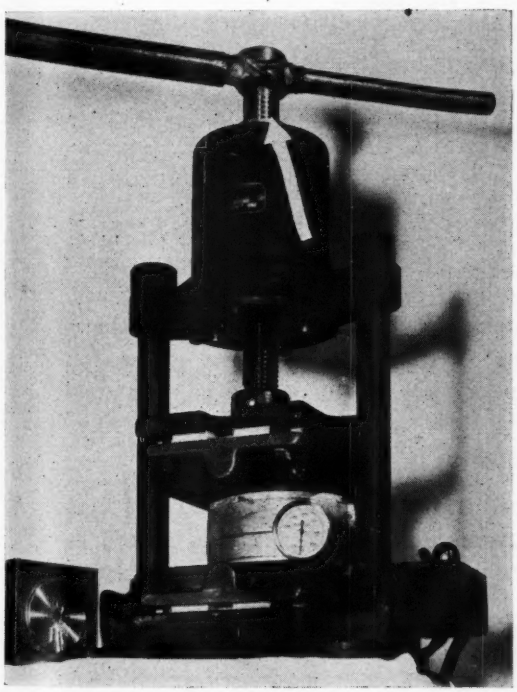


Fig. 18.

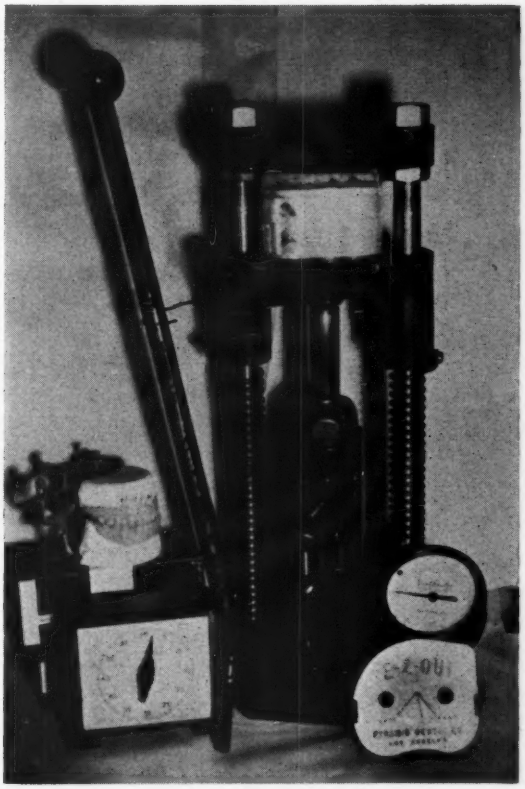


Fig. 19.

Fig. 18.—An S. S. White Resovin press with regulated pressure and temperature.
Fig. 19.—A hydraulic press with the pressure indicator.

MATERIALS

Cold Base Materials.—Any standard acrylic product which can be polymerized in a mold, in twenty minutes, under a pressure of 800 psi, without the application of heat, is primarily acceptable as a denture base material if it can be formed into a ½ oz. specimen free from defects and voids. The monomer must be clear and free from any evidence of viscosity. It should volatilize quickly on a slab in the open air. The *polymer* must be acid free, dry, and comparatively soluble in the monomer. The particle size of the polymer should be extra fine and "glaze" free, and the coloring should be of tested stability. When mixed

together, there must be a smooth, binding union between the powder and liquid. When the mix is ready for packing in the flask, it must not contain any dry chips or crusts.

Casts and Investments.—Extra hard casts and investments are unnecessary, and it is recommended that a good stone and plaster mix be used for the cast and for a protective support over the teeth. (See Technique.)

Separating Media.—Tin foil, or some tin-foil substitute, can be used. (Alginate films are often forced into the acrylic base.) If plastic teeth are used, a good commercial separating liquid may be applied as a coating over the teeth. It should be one which will dry quickly and will peel off readily after processing.

It is unnecessary to mention the other ordinary laboratory appliances, but good tools and equipment will save both time and labor.

TECHNIQUE

Printed instructions usually accompany the commercial products, but it is suggested that the operator follow the technique to be described here. A test case should be made up in order to become familiar with the working properties of the material before undertaking the processing of a practical appliance.

PRELIMINARY STEPS

Impressions.—No instructions on impression making will be described here, although my preference is for a functional or tissue displacement impression for difficult cases. If post damming and peripheral sealing is desired, it should be very slight, as the cold-processed material does not draw away from the cast, and exacting details are produced and maintained in the finished denture.

Casts.—As previously indicated a cast material consisting of 20 per cent stone and 80 per cent plaster by bulk is satisfactory. The mix ratio should be approximately three of powder to one of water. (Some stones and plasters require more water.)

Waxing and Setting up Teeth.—If care is taken to avoid tissue displacement in obtaining centric relation records, and a recheck of the mounted casts and tooth setup made, the usual complaint of "opening the bite" may be avoided.

A good baseplate wax, for example, Kerr's Hard Regular, should be used. A soft sticky wax *leads* to difficulty. Waxing should follow the natural anatomy of the gums. Normal tissue fullness should be reproduced in the region of the interdental papillae. At the cervical margin of the teeth, the carving should be sharp and well defined. No wax should be permitted to remain on the exposed crowns of the teeth.

Plastic Teeth.—The advent of new extra-hard, solvent-resistant plastic teeth, like Myerson's, and even the softer type acrylic teeth manufactured by Justi, Trubyte, Austenal, and others have presented a problem for tooth retention using cold, rapid polymerizing base materials. This was particularly true when

the root ends of the teeth were not perfectly clean. Wax, dirt, or grease prevents a good bonding union between the teeth and the base material. Mechanical retention may be made in the acrylic teeth in the shape of the porcelain diatoric teeth, by the use of ordinary round burs (size 3 and 7). Satisfactory retention may also be obtained by applying a thin resinous coat to the exposed cervical ends of the flasked teeth, before packing the flask with the cold self-curing mix (see Packing).

Flasking.—After the teeth are carefully articulated and waxed into position, the cast and setup are removed from the articulator, tin foiled, trimmed, and seated in the flask in plaster of Paris. The plastic is shaped in such a way as to form a slight angular boxing. This procedure will produce a lock to trap the acrylic mix within the mold. The purpose of investing the cast in this manner for the cold materials is not only to insure greater density of the resin but also to reduce the amount of heat generated during the short polymerizing period. No waste gates or escapeways to provide space for surplus material should be made. The flasking is completed, and the investing material is allowed to harden completely.

The flask is carefully separated in hot water, and all wax is removed from the teeth and cast by flushing them with boiling water. The grease or wax residue is removed from the teeth and cast by brushing them with a hot solution of a detergent, such as 2 or 3 per cent solution of Tide or Dreft.

Preliminary Procedure.—The flask, investment, and mixing equipment must be cool and dry. Care must be exercised to prevent any grease or water from coming in contact with the mixed material.

Mixing.—The proportion of a mix of the cold base material, which is usually recommended by the commercial manufacturers of these products, is one part of the monomer to three parts of the polymer, by volume. The average denture requires approximately 30 c.c. (1 oz.) of powder and 10 c.c. of the monomer.

If plastic teeth are used, a coating of a thin mix of the plastic is made over the cervical ends of the plastic teeth. It serves as a bonding medium between the teeth and the base material. It is prepared in a clear dappan dish by adding a small amount of polymer to a "fast" monomer (plastic filling type) with as little agitation as possible. The thin creamlike mixture is applied immediately to the cervical ends of the teeth in the flask by a small brush. A second coating may be used if necessary.

The base body mix of acrylic should be ready for the final packing of the flask before there is any "setting up" or crust formation on the primary coating on the teeth. This technique eliminates the possibility of any separating lines in the finished denture.

The importance of proper mixing of the cold materials must not be overlooked. To form the thick doughlike base, the powder is added to the liquid with as little spatulation as possible. Jolting the jar is the best means for polymer saturation, elimination of air, and prevention of a surface crust formation.

The jar is closed and allowed to stand for two minutes. (Gases from the mix will keep the enclosed mass moist and free from crust formation.) The entire mix is then removed from the jar, and with clean, dry hands, the mass is kneaded to a doughlike consistency that is free from stickiness. The mix is then ready for the packing in the flask.

Packing.—No trial packing should be attempted, and the use of wet Cellophane is to be avoided if possible. About one-fourth of the mix is formed into a strip and pressed down over the invested teeth. (In packing partial dentures, part of this portion of the material is also forced under the exposed metal framework.) Then the remaining portion of the mix is added to it, and the cast half of the flask is seated into position, and the flask is closed in the press. Even though no waste gates are used and even if the mold form is designed for trapping the mix within the mold, there will be no difficulty in extruding the excess material from the flask. Trial packing is avoided when cold materials are used because surface-drying crusts will quickly form during a piecemeal packing, and a disturbance of the rapidly solidifying mix will usually lead to complications.

Processing Time.—There are many reasons for using a material which will solidify in twenty minutes, but the two most important are: the timing for the correct primary cementing action and the heat control. There is no objection to allowing the flask to remain in the press somewhat longer than twenty minutes, but it is best to remove the denture from the flask and investment as soon as possible after the base has reached a point of "set" solidification.

It may be noted that when the appliance is removed from the investment, the excess "flash" on the land is soft and has a distinct odor of the monomer. It should be understood that the hardening reaction of the processed denture will be hastened when it is removed from the investment and exposed to the air. The excess of base material is removed, and the denture is washed in a warm alkaline or soapy solution, which will remove the monomeric odor. The denture is then trimmed, polished, and finished in the usual manner. It can be inserted into the patient's mouth immediately without fear of irritation by the monomer.

The introduction of the cold-processing acrylic products has resulted in many dental restorative failures. These failures may be attributed to both the commercial manufacturer and to the dentist himself. The instructions from the manufacturer leave too much to the discretion of the technician or the dentist. Also, the average dentist is inclined to practice a certain amount of experimentation. An early belief in the simplicity of denture repairs with these self-curing products often resulted in the ruin of the dentures being repaired. A monomer or other solvent applied to a hot-processed appliance will result in a series of checks, and often these defects are practically obscured in the pink denture base. Nevertheless, the damage is definite and permanent.

Cold material may be used for repairs and relines on both hot and cold dentures, but the use of regular hot base material for such purposes on self-cured dentures should *not* be attempted. The present self-curing denture base materials have not yet reached a par with the structural hardness, stability of polished

luster, retention of teeth, and other properties of the hot denture base materials. But for molding accuracy, reduction of internal strains, workable properties, and tissue adaptation, the cold products are superior to the hot acrylic products.

SUMMARY

1. Rapid, cold processing materials hold an important place in prosthetic dentistry and have many undisclosed possibilities.
2. Successful solidification of a mix depends primarily upon:
   A. The quality of the product.
   B. The catalyst used.
   C. The size and character of the polymer particles.
   D. The correct proportions of the mix and manner of manipulation.
   E. The size and form of the mold and technique used in processing the case.
3. Trial packing is not desirable. Water, grease, or crust should not be permitted in the mix.
4. Particle cementation in combination with polymerization, where a bulk of material is used, may be accomplished under high-pressure molding. Likewise, cementation and lamination is possible without pressure.
5. Internal chemical heat may be reasonably controlled by causing its rapid dissipation into the walls of the mold.
6. The flash or extruded part of the trapped mix carries with it a certain amount of free (scavenger) monomer which insures a greater density and solidity of the material in the mold section.
7. Polymerization, once in motion, will continue after the denture is removed from the flask.

CONCLUSIONS

Cold denture base products as compounded and manufactured today are still lacking in some of the physical properties of the regular hot denture base materials. This is especially true if the American Dental Association Specification No. 12 for Certification is required. It is hoped that the Association will, in the near future, set up a new classification and requirements for the cold polymerizing denture base material. Cold products possess certain outstanding qualifications as a denture base material. The following may be listed as their advantages: (1) Elimination of applied heat. (2) Internally generated heat control. (3) The flask and investment are never warm. (4) Superiority in cast adaptation. (5) Greater pressure without danger of breakage. (6) Processing time is twenty minutes. (7) Denture may be removed from the flask immediately. (8) Less internal strain. (9) Material is dense without voids. (10) Denture may be finished and polished at once. (11) It is time saving and simple to process. (12) Little equipment is necessary. (13) Generated heat is self-limiting. (14) Absence of mouth irritation. (15) Molding details are unsurpassed. (16) Distortion from temperature changes are reduced to a minimum.

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ACRYLIC RESTORATIONS BY THE OPERATIVE NONPRESSURE PROCEDURE

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THE ADVANCE of methyl methacrylate resin into the field of operative dentistry marks a new era in dental reconstruction, and sets a new high in esthetic expectancy. Results, so far, appear to predict that chemistry has well adapted the fast, self-curing acrylics to the requirements of operative dentistry. Physical properties which indicate its use in certain type cavities also contraindicate its application in others. Although the range of its indicated use is being gradually widened, it is not the intent of this paper to pcure mehyl methacrylate or its co-polymers in the role of a universal restorative material, but rather to describe a method to be used at the discretion of the operator for all classes of cavities when esthetics becomes the predominant factor. The acceptance of the acrylics is due not only to their favorable qualities as a restorative material but also to the unfavorable physiologic reaction to the silicate cements.

The most effective manipulation is accomplished only when a procedure is in accord with, and takes full advantage of, the physical and chemical properties of the restorative material. A knowledge of the more important properties of the acrylics is a reassuring aid to the operator.

Methyl methacrylate is classed as an ester being the resultant product of the reaction between an alcohol and methacrylic acid, although it is not produced commercially in this manner. The use of an ester in restorative procedure is rather novel since silicates and base cements have long required phosphoric acid as the liquid component.

The relative viscosity[1] of the monomer at 25°C. is 0.59, indicating that its ability to flow is approximately twice that of water. A drop of monomer placed at any part of a cavity runs immediately to all surfaces. This property is also novel when compared to the rather highly viscous liquid component of silicate cements.

The monomer, when exposed, evaporates readily; its highly volatile and inflammable nature must always be remembered—keep it away from a flame.

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A comparison of the plastics, relative to the amount of water absorption, finds methyl methacrylate in a position between polystyrene which absorbs the least water, and cellulose acetate the most.[1] The methacrylates absorb 0.45 per cent of their weight in 24 hours at 25° C.[2] This property is often quoted as being capable of expanding the polymer sufficiently to compensate for the volumetric loss of polymerization; however, numerous tests on samples of sizes *approximately operative restorations* fail to show any measurable weight or dimensional gain.[5] If there is any compensatory volumetric gain by water absorption, it is not measurable by instruments capable of evaluating 0.0001 inch.

Specific gravity and density values are important because their variation accounts for the amount of volumetric change of liquid monomer to solid polymer. Obviously the polymer, which is not involved in a chemical change when plasticized by the monomer, is dimensionally stable and has a density value[1] of 1.19. The specific gravity[1] of the monomer of denture acrylics processed by heat is 0.95. The conversion of monomer to polymer in denture acrylics represents a volumetric loss of 21 per cent, which amount is applicable to the operative acrylics since any difference in monomer specific gravity, due to the added promoter, would be so slight that it is negligible. This high value is a theoretical calculation as far as restorative procedure is concerned, the dimensionally stable polymer lowering the volumetric loss of the mixture in proportion to the amount of polymer wetted with monomer.

DENTURE PROCESSING VERSUS ACRYLIC RESTORATIONS (PRESSURE METHOD)

The pressure method of operative acrylic restorations is undoubtedly an adaptation of the laboratory packing and processing of acrylic prostheses by the split flask compression method. Pressure was used for vulcanite, and a similar technique was carried into processing the acrylics. The packing and processing of an acrylic denture necessitates the use of heavy pressures by spring clamp or injection molding, but this does not constitute a reason why operative repair should follow a like pattern, the conditions of both procedures being entirely different.

First, operative procedures involve vital tissues. If the pressure method used so routinely in the laboratory could be transposed into operative work, its effectiveness would be questionable since a tooth and its approximating tissues are limited in their tolerance to external forces. The amount of pressure (other than occlusal forces applied parallel to the long axis of a tooth) that can be exerted on a tooth without a disturbance of the normal physiology is questionable. But regardless of any available data, it is therapeutically unsound to assume that the pressure principle as it applies to cast materials is applicable to vital structures.

Second, pressure for operative acrylics is mechanically limited. The initial volumetric loss of denture acrylics occurs in the mixing jar where the monomer and polymer mixture partially polymerize to the doughy stage prior to packing in the flask. In this stage of polymerization, it requires heavy pressure to

adapt it to the mold cavity and restrain the elastic memory of the material. The monomer-polymer mixture, before packing, must have attained a degree of polymerization sufficient to produce a resistance to flask closure, otherwise the pressure necessary to force the mass into the recesses of the mold cavity is lessened to the small amount sufficient to squeeze out the excess. In denture processing, this necessary pressure is mechanically possible.

Although proportionately less, the operative acrylics used by the pressure method must be inserted into the cavity when they are partially polymerized, for identical reasons which are (1) to reduce the volumetric loss, and (2) to create pressure of the material against the cavity walls.

Pressure, by means of a clamp or similar device, may be exerted on the walls of a Class V cavity through the medium of the restorative acrylic. However, it is not mechanically possible to place a Class IV restoration by pressure, by any means other than the injection principle, especially when there exists an approximating tooth. The direction of pressure exerted in a Class V restoration is labio- or buccolingually against the pulpal wall; similarly, the direction of pressure in a Class IV restoration must be mesio- or distoincisally against the pulpal walls. The latter is not mechanically feasible since pressure clamps and similar devices deliver pressure only in a labiolingual line, and cannot be effectively adapted to produce forces in other directions, due to the complexity of the dental arch and the variety of cavity outline. The pressure method so adapted to denture acrylics lacks the versatility demanded by operative procedure.

Fig. 1 shows that transfer of pressure, or the force that is pushing the acrylic against the cavity walls, is proportional to the resistance of the material when the transfer medium (acrylic) is not entirely confined (as in the pressure method). The graph records the increase in pressure transferred, as it occurs with increased resistance of the acrylic. This indicates that the effectiveness of any pressure device used for operative acrylics is controlled by the resistance of the acrylic, which increases with the time degree of polymerization. We are not interested in the total amount of pressure a clamp or similar device is capable of exerting, but we are concerned with the amount of pressure that is exerted against the cavity walls through the medium of the acrylic.

The practical application of this experiment is that the acrylic, when in a plastic state capable of filling undercuts and irregularities of the cavity, is not capable of transferring the pressure from the clamp to the cavity walls. The acrylic has not been placed by pressure against the cavity walls; the excess has merely been squeezed out. This excess on the tooth then acts as a stop, limiting any movement of the matrix to produce further pressure. This defeats the purpose of pressure, which is to continually force the acrylic against the cavity walls as it draws away and undergoes the volumetric loss of polymerization.

Third, denture acrylics are processed by heat. This externally applied heat, plus the exothermic reaction, results in a slight expansion and subsequent volumetric loss due to polymerization. Self-polymerizing resins exhibit a progressive volumetric loss when they are used in small amounts *approximating the size*

of operative restorations. This is due either to the ineffectiveness or the rapid dissipation of the exothermic reaction.*

Other differences exist between operative and denture acrylics; the foregoing, however, shows that there is little similarity in procedures.

NONPRESSURE METHOD

The nonpressure method, which uses the prepared cavity of the tooth as the site of conception and termination of polymerization, takes advantage of the physical and chemical properties of the material. It is based on a principle of repeated replacement of the volumetric loss. The volumetric loss can never be eliminated as long as it is necessary to use the monomer; however, it can be compensated for.

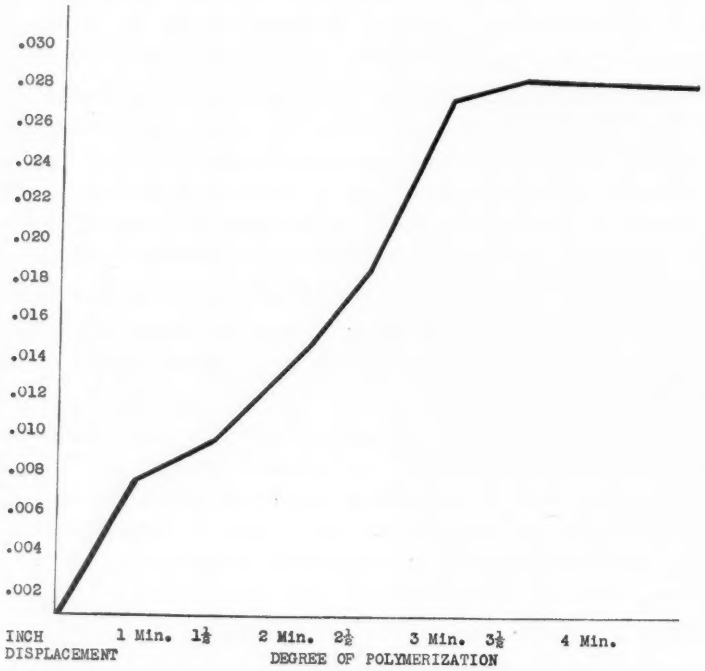

Fig. 1.—Transfer of pressure is recorded as displacement of a constant pressure load on a movable piston.

To prepare the material, 10 to 12 drops of monomer are put into a dappan dish. Polymer of the desired shade is placed in another heavy glass dappan dish which has been heated in a boiling sterlizer and lightly flamed. The polymer is kept warm throughout the procedure by passing the dappan dish through a flame four or five times. A second heating, during the building up, is usually all that is necessary. To distribute the warmth in the polymer, use a rocking motion, then tap or vibrate the dish firmly. Avoid stirring, which causes a

*When the heat is confined and not dissipated, they show a slight expansion prior to contraction, most evident in resins developing a high exothermic reaction.[3]

trapping of air in the polymer. If more than one shade of polymer is desired, another dappan dish is prepared in a like manner. (Do not heat the monomer, it is inflammable.) The monomer and warm polymer are now transferred in very small amounts to the prepared cavity. The restoration is built up and overcontoured in much the same manner as for a gold-foil restoration.

The transfer is made with a fine sable hair brush. Nos. 00, 0, and contra-angle brushes are necessary equipment (Fig. 2). No. 00 serves well for small cavities; large cavities indicate a No. 0. The contra-angle consists of a slightly thinned No. 1 brush on an explorer and is ideal for a lingual or posterior occlusal approach.

Certain aspects of the transfer should be noted and tried previous to the actual use of the material. Dip about 1 mm. of the No. 0 brush into the monomer. This amount of monomer will saturate and pick up a small bead of polymer.

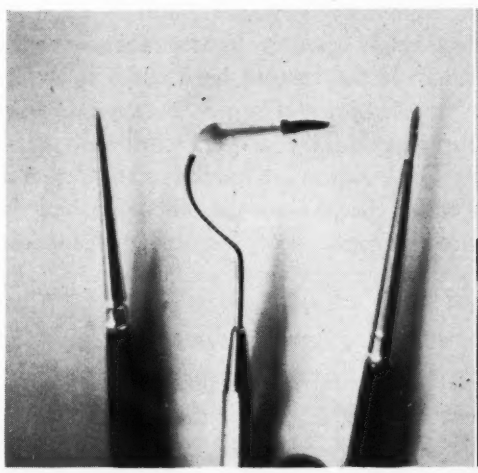

Fig. 2.

Fig. 3.

Fig. 2.—Sable or camel's hair brushes used in acrylic transfer No. 00, contra-angle and No. 0.
Fig. 3.—No. 0 brush with typical polymer bead, magnified.

Fig. 3 shows a No. 0 brush and typical polymer bead. If the brush is completely immersed in the monomer, it will fail to pick up any polymer, the monomer will flow to the polymer instead. The explanation of this is irrelevant, but it is important that the brush is not flooded with the monomer before the contact is made with the polymer. Any excess monomer can be removed easily by touching the brush to a blotter.

The procedure for building up the restoration is as follows: (1) Use a brush to dampen the cavity walls with monomer. (2) Place the *tip* of the brush in the monomer, then pick up a *small* bead of warm polymer, and place it into the cavity. (3) With the tip of the brush, pick up some monomer and place it on the polymer bead in the cavity, thus causing it to flow. Repeat steps 2 and 3 until the restoration is slightly overcontoured. An ordinary one-surface

cavity requires approximately eight additions. The smaller and more frequent the additions, the greater the accuracy of marginal adaptation. This building-up period must take a minimum of five minutes for a medium size cavity (such as a Class V), and proportionately longer for larger cavities. The building-up period for a Class IV cavity must take a minimum of eight minutes. The handling of this material is contrary to silicate and amalgam which require quick placement of the restoration before setting of the material. The acrylic restoration must be built up slowly. The use of a watch to time the interval from the first to the final application of the material is helpful.

It is necessary to apply some monomer directly to the restoration during the building-up period, to replace that which is lost by rapid evaporation. Sufficent monomer is added during the build up and contouring to maintain a slight glossy appearance, in preference to a dry granular sandy state. After the restoration is built up, with a glossy sheen throughout, it is covered with 0.0006 tin foil. It is allowed to set eight to ten minutes, and is finished with burs used with light pressure and at high speed. Coarse abrasives are not applied to the labial or lingual margins. If they are to be used, it must be done with caution, due to the difference in abrasion resistance between enamel and acrylic which causes a greater cutting away of the acrylic when the abrasive is applied equally to both substances. The restoration exhibits the best marginal finish and most accurately resembles the surface of enamel when finishing is done with burs used with light pressure and at high speed, exclusive of any abrasive or polishing medium.

THEORY AND PRINCIPLE OF THE METHOD

The main objective of the method is to secure perfection of marginal adaptation by compensating for the inherent volumetric loss of the material to infinity. When the acrylic is placed into the cavity, it suffers an appreciable volumetric loss. When the restoration is built up with repeated additions of acrylic under the conditions outlined in the nonpressure method, the volumetric loss in each application is replaced, or compensated for, by the next addition. The practical application coincides with the theory. If the material undergoes a volumetric loss of 10 per cent, a given volume 1.0 will lose 0.1, thereby reducing the volume to 0.9. If a second addition of the material is then made it will replace the volumetric loss of the initial amount, thereby restoring the 0.9 to the original volume of 1.0. The amount that was added (0.1), however, undergoes a volumetric loss of 10 per cent which reduces the over-all volumetric loss to 0.01. Repeated additions of the material reduce the loss to 0.001, 0.0001, 0.00001, and so on.

The gold-foil restoration achieves its perfection of marginal adaptation by a technique of repeated additions, and thus is somewhat comparable to the nonpressure acrylic procedure. Gold foil, after being placed into the cavity, undergoes a volumetric loss by pressure condensation. Acrylic undergoes a volumetric loss by physical change, but in each case the desired volume is attained with additional material.

A study of the operative acrylics reveals that: (1) the major portion of the volumetric loss occurs during the first five minutes of polymerization,[3] and (2) pre-heating the polymer reduces the final volumetric loss slightly and accelerates the rate of polymerization. This causes the volumetric loss to occur in a shorter period of time.[3] The idea is to accellerate the volumetric loss of each amount placed in the cavity in order that it may be replaced by the next addition, without making the procedure too lengthy. This is done by warming the polymer, which expells any moisture, causes more rapid evaporation of the monomer (thereby reducing the volumetric loss), and greatly increases the rate of polymerization and consequent volumetric loss. The time in which the greatest volumetric loss occurs has been reduced considerably by heating the polymer. The exact time is not measurable because the material begins to polymerize before it can be placed in a measuring instrument. The method, therefore, requires that the polymer be *warm,* and that the *time interval* be observed as outlined in the method.

The maintenance of a glossy sheen is an indication that sufficient monomer exists to eliminate any porosity and that the material is available in a state in which it is capable of contacting all cavity surfaces. It thus acts as a reservoir to replace the volume of previous applications which has been lost. The low viscosity of the monomer makes this action possible. Replacement of the monomer which is lost by evaporation is necessary also during the building-up process. By using the brushes as recommended, it is hardly possible to have an excess of monomer due to a near equilibrium of the small amount of monomer the brush can apply and the amount lost by evaporation which is accelerated by warmth of the polymer.

The minute spaces between the polymer particles are filled with monomer which, when evaporated out, leaves the polymer standing alone. Thin tin foil adapted over the built-up and roughly contoured acrylic decreases the rate of monomer evaporation, thus preventing a granular appearing surface. A glassy, easy-to-finish surface will result, after polymerization, if the restoration is dampened with monomer just prior to placing the tin foil.

CONTACT COMBINING POWER

The adaptation of the operative polymers to the nonpressure procedure varies with their contact combining power. When 0.1 Gm. of monomer is dropped into an excess of its respective polymer, it is capable of wetting and retaining a constant amount of polymer (in Gm.).

If the polymer could be used in operative procedure, without using the monomer, it would be ideal. Since this is not possible, and the monomer is necessary, it follows that proportions should be used which most nearly approximate the ideal. Therefore, polymers with the highest contact combining power should be used.

It is evident that the low viscosity of the monomer (which makes the instant flow of each addition possible) is most effective when in combination with the higher rated polymers. The values vary as much as 100 per cent.

The esthetic expectancy is more apt to be fulfilled with the higher rated polymers since the various media which are used to shade or color the resins are carried by the polymer and, as the amount of monomer is increased, the final shade is different from that of the polymer and tends toward crystal clear.

Less volumetric loss is associated with the higher rated polymers, but this reason is of lesser importance since the procedure is compensatory.

TOILET OF CAVITY

Dryness of the cavity walls is as essential for the acrylics as for other restorative materials. Freedom from moisture must be maintained during the building up of the restoration.

The monomer, when in contact with phenol or any essential oil, acts as a solvent and fails to polymerize in the desired time. A zinc oxide eugenol base is contraindicated and, if it is used as a temporary measure, it must be removed, and the cavity wall flooded with alcohol and dried. Any approximating areas having a eugenol base should be isolated with foil. The slightest trace of eugenol picked up by the monomer will result in failure of the restoration.

CAVITY PREPARATION AND RESTORATION

Generally, the same principles of cavity preparation are used for acrylic as for amalgam or silicate restorations. The undercuts are not accentuated as is sometimes recommended.

The preparations for Class I and V cavities are the same as for amalgam. The restoration is built up, overcontoured, and finished to the desired anatomy.

Clinical experience with amalgam and the gold inlay in Class II cavities is so favorable that the use of acrylics is remote in them. In those instances, however, where the operator selects an acrylic resin for exceptional esthetic requirements, the cavity preparation is the same as for amalgam. The restoration is built up slowly in a matrix which is accurately adapted and which will greatly reduce the marginal finishing time. This type of restoration should be examined periodically.

The acrylic resins are not generally indicated for Class II restorations, due to their comparatively high coefficient of linear thermal expansion. This undesirable property is accentuated in the posterior part of the mouth where a greater volume of material is used and where thermal changes are more concentrated. This is in contrast to the anterior portion of the dental arch where thermal volume changes are minimized due to the protective action of the lips and to the quick passage of foods and liquids from the anterior to the posterior portion of the arch.

To say that the acrylics are not indicated for surfaces which are subjected to the stresses of mastication is not entirely true, except in rather rare cases. What foods of the present-day diet require any considerable stresses for mastication? The abrasion resistance of the acrylic resins compares favorably to that of amalgam. The acrylics abrade or "wear away" only 7 per cent more

than amalgam.[3] It is important that the reason why they are generally contraindicated for Class II restorations is understood. Many operators are of the opinion that if the resins are too soft and abrade easily the defect can be remedied by the addition of more material. This will cause an abuse of the material, because it is generally not indicated for posterior restorations due to its high thermal volume changes.

The preparation for a Class III cavity is the same as for silicate. It is doubtful whether the acrylics will ever replace silicate cements in the small proximal cavity where the pulp is protected by a heavy dentinal wall. The ease of manipulation of the silicates is in their favor. When extension for prevention is practiced or when the cavity is large, the acrylics are indicated.

Place a small stainless-steel strip interproximally to limit the flow of material. Build up and overcontour the restoration with a No. 00 brush. The contra-angle brush may be necessary for the lingual. Cover with foil and, after polymerization, finish.

The Class IV restoration involving the angle of anterior teeth is probably the most difficult. The unsatisfactory features of gold and silicate have lead many operators to the use of the full jacket crown. The acrylics, however, are an excellent medium for this class of cavity.

Fig. 4.—Class IV cavity preparation for acrylic. Labial and lingual box are of reduced size in comparison to lingual dovetail employed for retention of inlay. High esthetic value of acrylic makes labial retention possible. Axial wall is grooved. Gingival shoulder is definite.

The cavity preparation for the acrylics includes a lingual and labial box of reduced size in comparison to the lingual dovetail employed for retention of the gold inlay (Fig. 4). The axial walls are most favorable when they are grooved in a design typical of the gold-foil preparation. Since the retentive factors are great, their size can be minimized, thereby conserving structure.

The procedure for Class IV restoration is shown in Fig. 5. *A* represents the foil matrix against which the acrylic is built up. The proximal and lingual will require little finishing if the foil is adapted and contoured for these surfaces. To contour and to avoid an excess on the proximal, it may be necessary

to build out the approximating tooth surface with soft wax which must be completely covered with foil. The acrylic is built up with labial and incisal excess (*B*). The foil is then folded over the acrylic (*C*), and polymerization allowed to continue for about eight to ten minutes. The foil is then removed and the restoration completed (*D*). The labial and lingual surfaces are finished with burs used lightly and at high speed. The proximal is finished with abrasive strips. The best esthetic result is obtained when finishing is done with burs drawn over enamel and acrylic surfaces simultaneously, using the enamel as a guide. Avoid the use of abrasives and polishing agents which will cause a marginal discrepancy which is due to the greater cutting away of the resin when the abrasive is applied equally to enamel and resin.

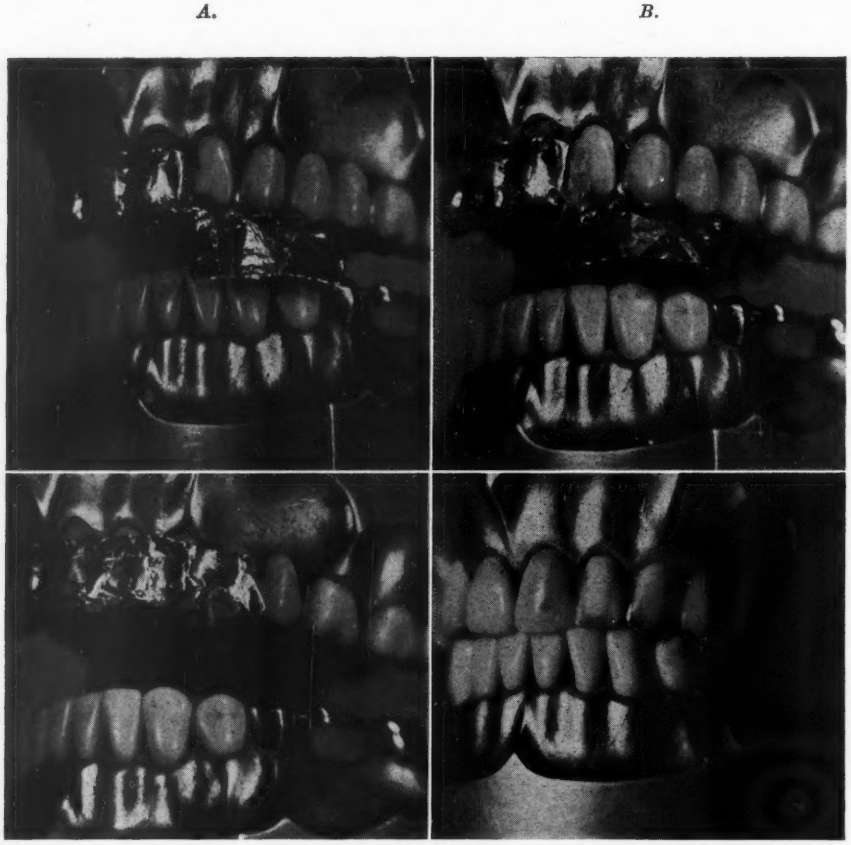

Fig. 5.—*A*, Class IV cavity preparation and foil matrix.
Cavity is filled with blue wax for photography.
B, Showing the labial and incisal excess.
C, Foil folded over acrylic to reduce monomer evaporation.
D, Finished acrylic restoration.

Does the nonpressure procedure prove superior, experimentally? How accurately is a cavity filled with self-curing acrylic by this method?

Fig. 6 shows the specially constructed steel mold which was used for experimental study. The diameter of the ground cavity of the mold is 0.2680 inch. After this cavity was filled with acrylic by the nonpressure method, the sample was removed and measured. The mean average of ten samples was 0.2677 inch which is a negligible dimensional inaccuracy of 0.0003 inch. The acrylic was accurate to within 1/10 of 1 per cent.

Due to the depth of the mold, it is hardly possible to test the accuracy of the pressure method in a manner that is comparable to the pressure as it is intended for operative acrylics. However, other tests were made with the mold, using pressure as it is applied by a spring clamp, and a piston which accurately fits the cavity and entirely confines the material. This method is near perfection for accuracy because the spring pressure forces the acrylic against the cavity walls and compensates for the volumetric loss of polymerization. The results of these tests show the same negligible inaccuracy.

This type of pressure, developed by an accurately fitting piston which completely confines the material, is not to be confused with pressure as it is intended

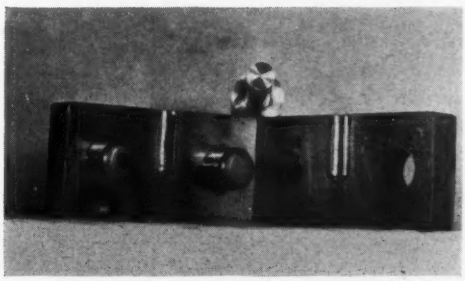

Fig. 6.—A split mold was used to facilitate removal of acrylic samples.

in operative procedure by means of spring clamp and matrix. If a comparison is to be made, the operative pressure method will require the following steps for a simple Class V restoration: (1) After the cavity is prepared, a wax inlay pattern is made. (2) This is invested and cast. (3) The fitted casting is then attached to a spring clamp. (4) The pre-mixed acrylic is placed in the cavity and the clamp is applied to force the inlay into the cavity. Only in this manner will the acrylic be confined and true pressure exerted. Obviously, the procedure is not only highly impractical, but mechanically impossible for other types of cavities. The pressure delivered to the acrylic by any matrix, other than by an accurately fitting piston, is negligible. The compound foiled matrix ordinarily used in the pressure method is capable of transferring only sufficient pressure to squeeze out the excess. This excess on the tooth then acts as a stop, effectively limiting any pressure movement of the matrix, although pressure may still be exerted by the clamp.

The various cavity sizes of a drill gauge (Fig. 7) were used to test the dimensional accuracy of the nonpressure-placed acrylics. The volume range of the cavities appears to approximate prepared cavities as they might appear in

the natural dentition, and range in diameters from 0.089 to 0.189 inch. Selected drill gauge cavities were filled using the nonpressure procedure. After polymerization, the samples were removed with machined punches. If any discrepancy was present, it was not measurable. Each sample removed was identical in diameter to the reading of its cavity on the gauge. If there had been any volumetric loss, force would not be necessary to remove the samples from the mold.

When reference is made to a volumetric loss due to polymerization, it is noticeable that the words "shrinkage" and "contraction" are avoided. This is intentional because they are descriptive of volume loss in all directions, and when they are used in dental literature they are suggestive of poor marginal adaptation. This is not true of acrylics, which experimentally appear dimensionally stable in all areas in contact with the confining surfaces of the cavity, when the initial molecular arrangement is unchanged. This is proved by placing some monomer in a concave glass dappan dish and adding polymer until no free monomer exists. This mass, if allowed to completely polymerize, without mixing or changing of the formation, will adapt itself so accurately that considerable

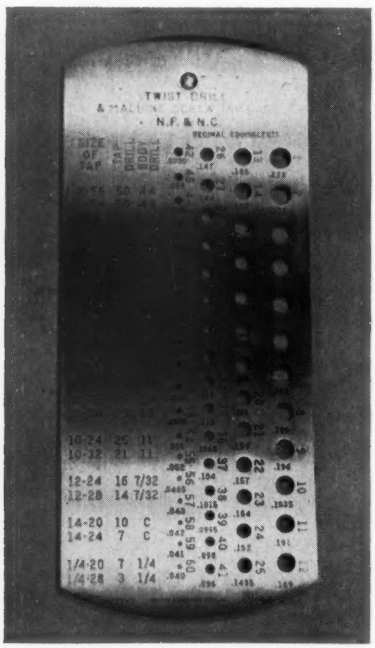

Fig. 7.—Drill gauge. Various cavity sizes were used to test the dimensional accuracy of the nonpressure-placed acrylics.

force is necessary to remove it. The initial molecular arrangement in this case has not been altered, and if the acrylic in contact with the confining surfaces of the mold had not been dimensionally stable, or had contracted, the acrylic would draw away from the glass and be easily removed. There has not been a decreased volumetric loss for the mass, but the total volumetric loss has ap-

parently been concentrated and confined to the exposed surface which, if originally flat, will show a marked concavity.

If a monomer-polymer mixture is allowed to partially polymerize and is then removed from the dappan dish and replaced with pressure in the same or different dappan dish, it can, after complete polymerization, be easily removed. It will almost fall out when the vessel is inverted. The initial molecular arrangement has been altered and the acrylic is not accurately adapted to the confining surfaces. The volumetric loss has not been concentrated and confined to the exposed surface, but apparently distributed over all areas. A shrinkage of the areas in contact with the glass has also occurred, minimizing the adaptation, as evidenced by the ease of removal of the acrylic.

The acrylics, therefore, exhibit the greatest dimensional stability in areas in contact with the confining surfaces of the mold, when the initial molecular arrangement is unchanged. The nonpressure procedure is in conformity with this property since it does not alter the initial molecular arrangement as the pressure method necessarily does. Test samples, nonpressure placed, in the mold cavity and drill gauge showed such accurate adaptation that mallet force was necessary for removal.

Tests for hardness performed on a standard Rockwell machine, using the red or "R" scale, show the highest hardness values for the acrylic which was formed by the nonpressure procedure, as compared to the acrylic formed by pressure. The variation is so small, however, that the hardness values by both methods can generally be considered equal.

A rise in temperature accompanies the pressure placement of acrylic restorations. Variations in temperature of either method appear negligible, since foods or heated impression materials account for a wider temperature range without any apparent pulpal involvement. The small amount of material involved in a restoration is hardly capable of any injurious thermal effects, due to the rapid dissipation and equalizing of temperature variations.

A critical analysis of any restorative material or method finally resolves itself into the question—How accurate is the marginal adaptation? The test to determine this is novel and comparative and can be described as a colorimetric evaluation of volumetric loss.

Restorations of different types were placed at one end of each of five glass tubes. The restorations placed were (1) amalgam; (2) acrylic, using the nonpressure procedure; (3) silicate; (4) acrylic, using the pressure technique, as it is advocated, with a foiled compound matrix and spring clamp; and (5) acrylic, using true pressure by a spring clamp acting on an accurately fitting piston which completely confines the material. Into each tube was placed an equivalent solution of the alkaline indicator phenolphthalein. The tubes were then connected to a central vacuum and simultaneously placed into test tubes containing equivalent solutions of weak sodium hydroxide (Fig. 8).

If the marginal adaptation of the restorations is perfect, the ends of the tubes are completely sealed, thus preventing any leak through of the sodium hydroxide when the vacuum is applied. Any imperfection in the marginal seal

will allow the alkali to leak through and react with the indicator, changing it from colorless to pink or red. The deeper the color, the less accurate the marginal seal. The test compares, by color, the ability of materials and methods to completely restore a cavity and approach perfection of marginal adaptation.

The acrylic, which was placed by true pressure with a spring clamp acting on an accurately fitting piston which completely confines the material, is on a par with amalgam (Fig. 9). Both represent perfection of marginal seal. This pressure method of acrylic placement, previously discussed, is ideal but ruled out of consideration, because it is hardly possible in dental procedure. Next in

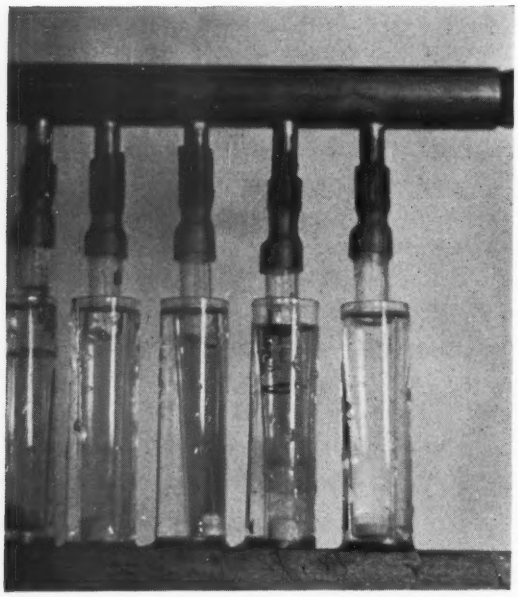

Fig. 8.

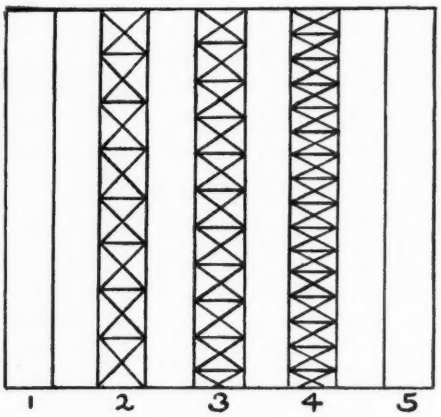

Fig. 9.

Fig. 8.—Colorimetric evaluation of volumetric loss. Restorations of different types are placed in the ends of the smaller tubes which contain equivalent solution of the alkaline indicator phenolphthalein. These tubes are connected to a vacuum by rubber tubing and simultaneously placed in test tubes containing equivalent solution of sodium hydroxide. Any imperfection in marginal seal will allow leak-through of alkali when suction is applied. The deeper the color of the indicator the greater the volumetric loss of the restorative material.

Fig. 9.—Colorless tubes. Amalgam (*1*) and true confined pressure acrylic (*5*) show perfection of marginal adaptation and no volumetric loss. The darkest tube (*4*) represents the greatest volumetric loss and poorest marginal adaptation—the false pressure method of spring clamp and matrix. The tube having the silicate (*3*) shows slightly greater volumetric loss than the nonpressure-placed acrylic (*2*).

the order of accuracy of marginal seal are (1) acrylic, placed by the nonpressure method; (2) silicate, and (3) acrylic, placed by advocated pressure method of spring clamp and foiled matrix. It is less accurate than silicate and considerably less accurate than nonpressure acrylic.

The conditions of this test are more demanding than those of actual use, due to the smooth surface of the glass tube as compared to a cavity wall. Regardless of this, the test is comparative. In order, however, to test an acrylic restora-

tion under conditions as close to the actual as possible, the following experiment was performed. A Class II cavity was prepared in an extracted upper bicuspid. The pulpal walls were removed, and the pulp canal enlarged so that an open passage extended through the tooth. A Class II acrylic restoration was placed using the nonpressure procedure, and the root portion of the tooth was connected to a vacuum of 28 inches of mercury. There was a drop in the vacuum of 5.75 inches in 60 seconds. The restoration and margins were then covered with wax to rule out any possible passage of air through them, and the vacuum was reapplied. The identical drop in vacuum of 5.75 inches in 60 seconds occurred, proving that the passage of air, or leakage, was not through the restoration or margins, but due to other causes. Under restorative conditions closely approximating the actual, the marginal adaptation or seal showed no imperfection.

SUMMARY

A study of the self-curing acrylics and methods of operative placement has been made. The findings indicate (in view of the many desirable properties) that the material is of questionable value as a restorative medium unless a procedure is adopted which compensates for the volumetric loss or shrinkage. The nonpressure procedure, which utilizes the physical and chemical properties of the material, and which has proved superior in comparative studies, achieves dimensional accuracy and approaches a perfection of marginal adaptation sufficient to regard the acrylics as acceptable.

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RESTORATIVE DENTISTRY—ITS PLACE IN MID-TWENTIETH CENTURY PRACTICE

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ATTEMPTING to evaluate restorative dentistry today, one feels as did a speaker who addressed a group of top-flight credit men recently in this city. He stated sensibly that it would be foolish for him to discuss credit on a lofty plane with the giants in the field, and that he would therefore discuss the subject from a modest point of view.

In the same way, it would be like bringing coals to Newcastle, or wind to Chicago, for me to attempt to discuss the technical complexities in the field of restorative dentistry before this audience. You, individually and collectively, are aware of the many problems. Let me, as did the credit association speaker, take a more modest approach.

First—of what do we speak?

1. The technique work which the undergraduate student is taught to do?
2. The clinical work he does before he graduates?
3. The type of service we see all too frequently?
4. Or that which is done by such of you who are devoting yourselves to fine dentistry?

—Perhaps we must consider all.

It will be assumed that you have a working knowledge of our history. We can then utilize our time in looking squarely at the present with the inner hope that our gaze may be sufficiently penetrating to catch some glimmer of things to come, and perhaps receive some help in guiding that future to the finest possible destiny.

A preliminary word about the vehicle of our knowledge—dental journalism. To be without it now would be unthinkable. We must therefore be constantly aware of the tremendous influence editors have upon our thinking and advancement, and the selection of such personnel in the profession must be kept at the highest plane of discrimination. Our publications have kept pace with the progress of the printing and publishing world as well as that of dentistry. Currently, we can find by a thoughtful selection of journals a coverage of research, procedures, and moral philosophy. Some of the larger periodicals are showing a tendency to avoid anything in the way of moralizations. The suggestion is ventured that the profession may obtain more uplift and be encouraged to improve the quality

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of their service as much by the occasional piece of "old-time religion" as by a restricted diet of purely scientific articles. A scrutiny of some of the papers published fifteen to fifty years ago will illustrate the point.[1,2]

What shall be our mental approach to an analysis of restorative dentistry in our day? Because you are among the most respected and capable in this facet of dental practice it would be easy to yield to the temptation to compliment you and continue to tell you, "You are the best." If that was done, you might agree, curl up like the contented cat that lies purring by the fire, and then not listen to the rest of what is to be said.

To forestall such a pleasant conclusion to the day, I will say that while it is granted that you are leaders in the field, yet naturally all of the leaders are not members of this Academy, and I am sure that you who are great will agree that, no matter how good you are or how much you know, there is someone someplace who is better or who knows more.

Just because a man is one of the best prosthodontists he is not automatically an authority on functional occlusion; a fine foil operator is not necessarily equally outstanding in bridgework; the clinician who has the most beautiful display models may or may not perform the same excellent quality of service in the mouth. Anyone who feels that he is positively on the top rung of the ladder of knowledge and ability must also realize that he cannot just stand there; someone else is building and climbing a higher ladder. Hence I shall not give you or myself the enjoyment of engaging in platitudes and back-patting.

To benefit most from an inventory of our field and ourselves we require confidence, humility, and an open mind. In such a frame of mind then let us restrict our terms of reference to a consideration of the present and the future of restorative dentistry under the headings of research, procedures, and education.

RESEARCH

Research has become more and more important through the years. By enlisting its aid and encouraging those with the necessary talents to devote their attention to it, much of the progress in the profession has been possible. Let it be said in passing that not all of the advancement has been due to pure scientific laboratory research; the clinician in dentistry is equally important. Without him the improvements in procedures and materials could not be evaluated, the theories of prevention could not be tested, and the ravages of dental disease could not be held in check pending the ultimate success of the research projects.

The contributions of research to restorative dentistry have been many. They can be segregated into those having to do with restorative procedures and those furthering prevention of dental disease. In the former, honor should be given to those who have contributed to the refinement of instruments and appliances, and to the consistently fine work of those at the National Bureau of Standards. As a result of their labors we are able, day after day, to produce uniform results which would have been the envy of our dental forebears.

In the matter of prevention it is difficult to keep abreast of developments. We are privileged to have ringside seats in an era of breath-taking developments:

chemical, such as the antibiotics and fluoridation; biochemical, such as nutritional controls, and mechanical, such as increased knowledge of function and occlusion. Yet this is only the beginning, and we must each keep constantly alert if we are to have any hope of knowing what is going on around us. Any attitude of laissez faire is suicidal.

What should be expected and sought from research of the future? The answer is self-evident. First, the positive means of preventing dental ills on a population-wide level by methods involving minimal disciplining of the people. Second, research may provide means of rehabilitating that which is left of the masticatory apparatus from the existent ravages of decay and periodontal disease, by procedures and materials which will demand less effort by the operator without sacrificing anything in degree of quality of service. In the matter of restorative filling materials alone, we still have to find some one material that has the permanence of gold foil, the strength of the gold inlay, the esthetic value of baked porcelain, and the ease of manipulation of the resins. One wonders if it ever will be found. The expectations of results from tomorrow's research, pure and clinical, are many and ambitious.

PROCEDURES

Let us next consider the actual, practical activities in restorative dentistry. Procedures and materials should be reviewed.

To properly introduce the subject of procedures, it is logical to refer to the one procedure which is a prerequisite to any and all successes in restorative dentistry. Without a complete, accurate examination an adequate diagnosis is impossible, and without a diagnosis any treatment is empirical and lacking in sound foundation. Of all the factors which contribute to a complete examination and accurate diagnosis, the use of the roentgen ray has been the most important. Its value has been stressed increasingly for over fifty years and is generally conceded. Unfortunately, there are still those who make only intermittent use of this great ally of good dentistry. Without its routine use preoperatively and postoperatively, the maximum in service to the patient is impossible.

After diagnosis, think of operative dentistry. Basic cavity preparation has been systematized for the past sixty years.[3] Many modifications have been advocated during that period. Some have been followed because they call for less skill and less time, even though they are anything but improvements in quality of workmanship or in service to the patient; they simply pacify the "speed merchants." Other changes have been the product of thoughtful evolution, until today the possibilities in refined, conservative cavity preparation are a tribute to the conscientiousness and high professional ideals of the many who have striven diligently to save more teeth and more tooth structure, without sacrificing the time-proved essentials propounded by Black[4-11]

In the field of bridgework, with its complexities and ramifications, the efforts of countless studious operators have saved this type of prosthesis from the fate of obscurity which was predicted for it as recently as 1914.[12] It has attained the status of being a branch of restorative dentistry which to be performed prop-

erly requires a high degree of skill in diagnosis, in analyzing functional forces, in mechanical engineering, and in digital dexterity. Such advancements have been possible due in part to greater attention to the need to free the oral cavity of infection and in part because of the improvement in materials at our disposal, as, for example, the gold alloys.

In spite of the possibilities today, however, those with any sense of critical analysis cannot but admit with shame that far too high a percentage of these prostheses are so deficient in meeting the demands of function, consideration of stress on abutments, health of surrounding soft tissues, marginal perfection of retainers, and restoartion of proper tooth form that they would be much better left out of the patient's mouth.

It is not too difficult to construct a bridge which adequately meets the needs of the patient. Fundamentally, however, it requires a greater interest in the patient's welfare than in the fee. An undergraduate student can be taught to construct a beautiful bridge on a Dentoform in a few weeks. But it takes an inborn conscience, sound grounding in basic technical knowledge, and the desire to serve well for a restorative dentist to be an operator in the highest sense of the word. It is because of possessing such attributes that most of you are here today, members of this highly respected group in organized dentistry. I am sure you are well aware of your obligation to guard your reputations well, and that you will never let your ideals flag or fail.

MATERIALS

Let us think briefly of the place materials hold in our phase of dentistry. What have been the recent developments, how do they compare with previous materials available, and what should be our aim in this respect in the future?

Look back over the past one-half century. In 1900, what filling materials were at hand? Gold foil, baked porcelain, amalgam, the gold shell crown, zinc phosphate cement, and gutta-percha.

At that time, local anesthesia was available only by the use of cocaine with its disturbing side effects. The field of painless dentistry through the use of safe local anesthetics was made possible with the discovery of procaine in 1905. In passing, is it not strange that there are still men in this day who pride themselves on working with callous indifference to the suffering of their patients, the large majority of whom would be eternally grateful for the consideration of a painless operation? Of course, it takes a minute or two and requires a little skill to administer an anesthetic painlessly—and it is the *patient's* tooth!

Through the year of this century new materials were added to the restorative armamentarium. The silicate cements were introduced in 1904, the gold inlay in 1907, and the acrylics in 1938. All have their own definite advantages and definite drawbacks. And still the oldest one remains the peer of them all in terms of permanence and conservation of teeth.

Perhaps this one material, gold foil, would bear some specific comment. Those of you who have your special interests in phases of restorative dentistry other than operative might be interested to know the present-day standing of

gold foil. This grandsire of filling materials, which was used in noncohesive form hundreds of years ago and then introduced in cohesive form in the middle of the last century, became increasingly popular in spite of the tedious techniques of manipulation in those early days. Procedures were refined gradually and as might be expected there were a few operators whose enthusiasm and ability led them to keep urging the others to more widespread use of gold foil.

However, in the constant search for easier methods many strayed away from the original and best material. It is interesting to observe that for the past twenty years, at least, one has been personally aware of similar pleas from the leaders in operative dentistry for the profession not to neglect the use of gold foil. Some have prophesied a continual loss of ground, while others expressed optimism in the eventual widespread "return to the fold" of gold foil. Apparently gold foil is a restorative material which will always be used, especially by those who have somehow or other become imbued with the ideal of conservativism and permanence in restorative work, even though the price in expenditure of energy or time may be slightly greater.

Some would say and even write that ". . . a small minority still insist upon singing the praises of cohesive foil, but theirs is a voice in the wildneress."[13] I would urge that neither you nor any of the examiners on dental state boards take such poetic double talk seriously. There are today hundreds of conscientious men in the profession, young and not so young, who, knowing that present-day refined techniques permit gold foil to be inserted rapidly and with a minimum of effort to produce the finest in restorative dentistry, are placing beautiful, permanent, inconspicious gold foils every day in their offices. It might be added parenthetically that it is one of the most lucrative procedures they practice.

Some say that gold foil is retained in undergraduate clinical programs and then required by state boards solely because it develops digital dexterity. It does have such value, but if that was the only reason for its use it would be better discarded. However, it is taught because it is the yardstick by which all other materials are measured and found wanting. It is the restoration which should be considered *first* in every case and set aside with reluctance only if the required repair is too extensive or if the operator has become incapable of doing what any dental student can be taught to do before he reaches the clinic.

The development of the cast-gold inlay has been mentioned. Without the application of the casting process to dentistry, the plane of restorative procedures would be entirely different than it is today. The research which has brought the technique to its present level of near-perfection constitutes one of the most intensive and voluminous projects in which dentistry has ever engaged. The work has been worth while, and the entire profession has benefited tremendously from it.

The newest material, the polymer-monomer resins is receiving profession-wide attention. These acrylics hold a good deal of promise in many respects, but they have some very definite deficiencies which must be overcome. It is well that some of the profession are approaching them cautiously. Too many, as in all lines of human endeavor, leap before they look or think. Judging by

past experience the material will be abused, damage will be done, and many teeth will be lost before the resins reach the ultimate degree of development possible for them. It may be that in some form or another they will be the perfect restorative material. Time, patience, research, and clinical evaluation alone will tell.

Perhaps within the second one-half of this century the ideal restorative material will be found. Perhaps by that time all dental decay can be prevented and the new perfect filling will be required only to care for the destruction which has already occurred. At least we can dream!

Aside from the restorative materials, other materials have been added to those at our command. In the field of medicine, there are new preparations which have revolutionized some phases of dentistry. An example is antibiotic therapy. We are all aware how that has altered our outlook on the pulpless tooth. Such impetus has been given the long-maligned "root-canal treatment" that the procedures involved have created a thriving specialty in the profession. Many thousands of teeth can now be saved for additional years of healthy service as a result of endodontic treatment, when a few short years ago there was but little assurance that any treatment could save them.

In the field of impression making, the hydrocolloids have opened new vistas and new possibilities hitherto attainable only with difficulty.[14,15]

New instruments have been developed and are definitely altering our techniques of operating. There are the diamond instruments, carbide steel burs, and air-brasive. Each has something definite to offer.

The list of developments could go on and on but these serve as examples.

EDUCATION

Finally, consider the place of restorative dentistry in dental education and, vice versa, the role of education in respect to restorative work.

On the undergraduate level, technical procedures have always held a leading position in the student's training. At present, some tendency is noted to reduce this stress in favor of one or another new theory of education. This is resulting in the graduates of some institutions showing very inadequate knowledge of the basic fundamentals of working with their hands, in short—of practicing dentistry. I think you who are practical men realize that such a condition is to be deplored. Educators and the profession must remember that their graduates go out into the world to practice dentistry; the immediate dental need of the public is for treatment, and treatment is chiefly technical and manipulative in nature; only by practicing well and on a sound economic basis can the dentist maintain himself and his family on the level they and society expect. If the student is not trained to use his hands and eyes properly, one of two things will happen: he will perform his services very badly and the patient will be worse instead of better, or he will have to learn fundamentals *after* graduation and thus suffer economically through the loss of time. Either procedure is most regrettable when there is so great a need for more and better dental service.

Examiners on state boards who realize the importance of an understanding of so basic a concept as the proper preparation of cavities or the restoration of correct dental anatomy in restorations are worried and upset by the utter lack of such comprehension on the part of so many of their candidates. It is a problem which men on the restorative department staffs of the universities must meet and overcome. As has been stated, prevention, medicine, and research are all vitally important in dental education, but the majority of the men in dentistry must earn the necessities of life from the efforts of their own hands, and the public has a right to expect that those efforts will be skillful and proficient.

On the graduate level, there is a great forward movement. Ever-increasing numbers of the profession are seeking additional training and it is encouraging to see these programs being so eagerly attended. As a result, more and more specialties are developing. It is unlikely that that movement will get out of hand, and as long as the quality of service is being improved the means of achieving it is secondary.

SUMMARY

In summing up the results of this review, it would seem that restorative dentistry today can show as assets that it is contributing to a major degree in the maintenance of public dental health with service which is progressively more functional, more conservative, more esthetic, more durable, and more painless than ever before. Further, it provides a clinical proving ground for the results of the findings of pure research.

On the debit side of restorative dentistry's ledger, its workers tend to be overawed by the excessive emphasis sometimes placed on research as such, and they present their own case very inadequately. The natural weaknesses of mankind assail restorative dentistry also. There is the ever-present precipitous rush after each new fad; there is the increasing tendency to do as little work as possible for as much money as possible. If only the ethics of professionalism could exert a more attractive influence! If only we would remember the statement of Dr. J. Leon Williams, "To believe greatly is to will greatly, and to believe and to will greatly is to achieve greatly." [14]

The goals toward which we must constantly strive are to presently serve the people with ever-increasing competence and dexterity in performing the work which their mouths require; at the same time we must keep our minds and hearts bent to the long-range goal of doing everything possible to eliminate the need for restorative dentistry through the development of preventive means. We may be sure that it is entirely unlikely that, within the lifetime of any of us, our very best efforts will not be required. There is so much to do and so little time!

Doubtless at the close of this twentieth century an evaluation will be made of the fifty years upon which we are now embarked. There is little question but that some of you men in this room will be among those who will be revered and respected as being among the all-time great in dentistry. It would not be right to name any whom, even now, we feel will be worthy of such gratitude.

When one contemplates the works of any great man, it is apparent that he does not work for glory as such, but rather because there is within him some indominitable, unquenchable force that drives him on and on to seek more and more knowledge and to assimilate it and impart it with lavish generosity. Such a force has marked the lives of those in dentistry to whom we owe so much this day; such a force is burning in the souls of some who hear these words. But great, or not so great, let us, each of us, earnestly strive to do all in our power to make our chosen field of dentistry take its full share of the task of alleviating and in time eliminating the curse of dental ills from the burdensome load of humanity.

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DENTAL ENGINEERING APPLIED TO INLAY AND FIXED BRIDGE FABRICATION

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ALL BODIES, however rigid or massive they may be, are beyond question deformed by the application of force. It does not matter how small the forces may be, the deformations are necessarily present. Mastication gives rise to forces which produce deformations of compression, tension, shear, deflection (bending), elongation, and torsion of highly significant magnitude in the investing tissues, the teeth, and the restorations. Today we will consider mainly the effects of these forces on the restoration.

DENTAL CEMENTS

The study of bridge or inlay function must be correlated with a study of the bond. In order to have a successful inlay or fixed bridge you must have a successful cementing or bonding job.

Dental cement is able to take great stress in compression; 13,000 lbs. per square inch, according to the National Bureau of Standards. Even when the compressive forces of heavy mastication are computed against the small fractions of a square inch which the inlays or abutment castings present to this force, the safe load on dental cement in compression is probably not exceeded. If the abutment castings, however, are so designed as to place the cement in shear or diagonal tension, failure of the bond may occur because brittle substances like dental or structural cements are weak in these qualities. Pure tension probably never occurs in the dental bond because dental cements are not adhesive.

Figures for shear or diagonal tension are not readily available for dental cements; however, if dental cement resembles structural cement in its physical properties, it is probably less than one-tenth as strong in diagonal tension as in compression. But the dental bond is not even as strong as this comparison would seem to indicate, for this ratio represents strength in bulk.

It is interesting to note, for purposes of analogy, that although structural concrete will take about 3,000 lbs./sq. in. in compressive stress, engineers use 600 lbs./sq. in. as a safe figure, 125 lbs. in shear, and only 50 lbs. in diagonal tension across a 45 degree angle. Figures for concrete in tension are almost never used, but in special cases, as when concrete is subjected to bending stress, 20 lbs./sq. in. is applied.

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At this point I will define the term "shear." If a test specimen which is weak in tension (as cement or concrete) is supported as if on a block and a weight or compressive force is placed upon the specimen along a plane directly above the edge of the support, the cohesion of the molecules of the specimen along this plane resist the weight. If the weight is powerful enough to overcome the cohesive force of these molecules they will "give up" or slip past each other, and the specimen will divide in two. This is shear, and a value can be assigned to the force necessary to produce shear in a given specimen. Now, if the weight is applied at some point removed from the support, the term applied to the test is diagonal tension, and the force necessary to produce a failure of the specimen is, as the figures above show, considerably less than the value for shear.

Dental cements act as a bond by a keying action. What we really have to consider is the combined strength of these keys to shear or diagonal tension. It is not clear whether the keys are in pure shear or whether, due to the shrinkage which occurs in the setting of all dental cements, they are in diagonal tension. When a cemented inlay is placed in axial traction, the strength of the cement bond will be determined by the strength of the cement in shear, the roughness of the interface between the inlay and the tooth, the irregularities of the inlay and the tooth, the areas involved in the bond, the pitch or taper between opposing walls of the cavity, and the thickness of the bond. If it be assumed, for a hypothetical case, that the keying of the cement occurs at 90 degrees to the retractile force, the relations of all the factors may be expressed by the equation:

$$\text{Strength of the cement bond} = K \bullet f\left(n,c,A,\frac{1}{d}\right)$$

Where K = a constant denoting shear strength of the cement in bulk
n = number of the projections
c = cross-sectional area of a projection
A = areas of tooth and restoration involved in the bond
d = distance between opposite faces of the bond

From the foregoing, n and c become progressively smaller values as casting accuracy and cavity rectitude improve. Since n and c are not at the control of the operator except in a negative sort of way, A and d are the important factors.

Two important conclusions follow from this study: (1) It should be regarded as axiomatic that the coupling between the abutment castings and the teeth should be such that the deflection and torsion set up in the prosthetic structure place the cement under the abutment castings in compressive stress. In other words, cavity preparation should be such that there is a mechanical coupling between the inlay and the tooth. We must not depend upon cement to take the stress in shear or tension except in direct axial traction. (2) Prosthetic structures which subject the bond to great shear stress should be retained by rather large abutments such as the three-quarter or the full jacket.

STUTEVILLE'S WORK

If we make use of the research of certain men, Stuteville[1] for one, we learn that the roots of teeth move in the sockets when load is applied eccentrically to the crown of the tooth. As a result of his studies Stuteville reported that the roots do not move bodily, but that they turn on an axis of rotation which lies in the apical third of the root of the tooth. In the case of multirooted teeth, the axis of rotation is in the bone septum between the roots of the tooth. When a lower molar tooth is tipped mesially the mesial root goes down while the distal root comes up slightly.

EXPERIMENT WITH CARDBOARD MODELS

If we make cardboard models of teeth and pin each model with a straight pin to a drawing board at this axis of rotation, and then place a cardboard bridge over these teeth, we can simulate and study the behavior of a dental bridge in greatly magnified size. The use of cardboard models is a device frequently used by engineers when they are studying an unfamiliar problem. When we do this experiment, we find that the cardboard models of the abutment teeth move very little on these axes of rotation; most of the movement is in the structure, that is, the bridge or beam. Consequently we may assume that if the periodontal membrane is capable of standing a biting force of 60 lbs., dental bridges are bending similarly by the occlusal loading.

When one considers the magnitude of the biting force and if we may assume that, at least in a fixed bridge, the teeth are not rotating appreciably, the stresses set up in the abutment inlays as well as the bridge structure must be very significant.

ENGINEERING EXPERIMENT

A dental bridge is nothing more than a beam between two abutments, just like a plank across a creek or a structural bridge. The latter is only a very thick beam supported at the two ends or abutments. If we take a beam which is freely supported at the two ends, and place a concentrated load upon it at the mid-point the following happens: All the molecules from the central plane upward are squeezed together or compressed and all the molecules comprising the lower half of the beam are pulled apart or stretched. Through the center, there is a row of molecules which is neither compressed nor stretched which engineers call the "neutral axis." The "compression" or "tension" is progressively greater as we consider planes farther and farther away from the neutral axis.

$$\text{DEFLECTION VARIES AS } \frac{1}{\text{DEPTH}^3} \text{ OR LENGTH}^3$$

There is something strikingly peculiar about bending or, as it is usually termed, "deflection." Deflection varies inversely as the cube of the depth and directly as the cube of the length. This may be illustrated and proved thus: Two slats are cut off the same $2 \times 4''$ piece of lumber, one being twice as thick

as the other (¼" and ⅛"). If first one and then the other is placed upon a couple of blocks, separated, let us say, by two feet, and a weight is placed upon the slat at its mid-point, the thin slat will bend eight times more than the thick one. If the thin slat were one-third as thick as the other, it would bend twenty-seven times more. Now if the weight and the slats remain the same, but the supporting blocks are moved closer together, say to 1 ft. apart, and the weight is again placed at the mid-point of either slat, it will be found that the bending is only one-eighth as much at 1 ft. as it was at 2 ft. In other words, doubling the length of the slat makes it eight times more flexible; and if the length remains constant, reduction of its thickness by one-half also makes it eight times more flexible. We should take advantage of this fact because we want our bridges to be stiff so that bending will not wrench the inlays loose from the teeth, and we want our inlays stiff so they won't crumble the cement under them.

The rule that materials bend inversely as the cube of the depth and directly as the cube of the length is a law which holds for any substance whose modulus of elasticity in tension equals or approaches that in compression; therefore, this rule applies to practically all springy materials with which we are familiar, such as bone, dentine, cardboard, wood, steel, gold alloys, plastics, and, within a certain temperature range, even wax. This same relation of mass with respect to length and depth also holds as well for the components of the abutment castings, that is, the isthmus, dovetail, and box, as for the bridge span.

All other things remaining equal, a two-tooth bridge will bend eight times as much as a one-tooth bridge, and a three-tooth span will bend twenty-seven times as much. The thicker the proximal box, the less by a cubed power, the bending of this component. Since the isthmus of a mesiocclusodistal inlay is longer, it is substantially more flexible than the isthmus of a proximocclusal inlay; consequently a mesiocclusodistal has less resistance to displacement than a simple proximocclusal.

For physiologic reasons it is desirable to cut abutment castings shallow. From our study, however, an abutment with a thin proximal flange, like a pin-ledge or thin-slice preparation, is undesirable because the thin flanges are weak and can be displaced sidewise. In the case of the pin ledge, as a result of the bending of the pontic and deflection of the thin proximal flange, torque is applied to the pins and lingual envelope of gold. Since these components of the pin ledge are tenuous, they cannot take stress of the magnitude occurring in the bridge structure without excessive bending themselves. The bond is crushed by the excessive torsion, and in a short time the margins of the abutment begin to leak.

It can be demonstrated experimentally by the cardboard models previously referred to that when load is applied to a fixed bridge, the flange of a mesiocclusodistal abutment which is opposite to the soldered joint tends to separate or move away from contact with the tooth. This is the result of the shortening of the occlusal fiber of the pontic by the arc of deflection. The displacement of the opposite inlay flange can be prevented and stiffness of the proximating flange of

the abutment can be promoted simultaneously if the two flanges are united by an external strap or "web" as in the construction of a three-quarter crown.

When it is considered desirable to keep the primary abutment of a bridge as small as possible, good engineering design requires the placement of a dowel whose base is lower than the pulpal floor of the preparation. For the reason that such dowels are not to be placed close to the pulp, they take the form of dovetail extensions and semicylinders of gold alloy in the buccal or lingual tooth structure. The dowels provide mechanical resistance to displacement. More will be said on resistance form later.

The conclusion from this study is that we need strong abutment castings for long span bridges because deflection tends to wrench the castings loose from the abutment teeth. This means we have to have square-cut, shallow, but extensive abutment preparations for bridgework, and this is where the indirect system works best. This also means, however, that we have to have a good impression-making and converting system.

While the subject of deflections of dental bridges was treated as though the bridge were of homogeneous material and uniform section, the same principles apply to ordinary bridge construction. Bridges which employ porcelain as a veneering material will be considerably stiffer in a given section than those employing plastics because porcelain has a much higher modulus of elasticity, 16,000,000 to 45,000,000 lbs./sq. in. However, since porcelain is also brittle, it finds its best application to bridgework on the "compression" side of the bridge pontic. Plastics with a modulus of elasticity of 400,000 lbs./sq. in. are so soft and yielding that the metallic part of the pontic must be so designed as to not only carry all the load in chewing but it must do this without excessive deflection and it must support the plastic.

INTERMAXILLARY TORQUE

Intermaxillary or mesiodistal torque may occur as a result of the negative as well as positive forces of occlusion. When one chews sticky food with a posterior cantilever bridge, the negative forces acting on the pontic tend to pull the lug out of its seat in the secondary abutment, and apply torque to the primary abutment. In the positive phase, if tough fibrous food, such as the crust of bread, is chewed on a posterior cantilever bridge, the unground cusps of the primary abutment tooth may engage the crust first and great force may be brought to bear upon them before the bridge structure comes into occlusion. If this occurs the primary abutment tooth may be depressed momentarily on the axis of rotation previously mentioned. Since the cantilever is being supported at the other end, and since it is conceivable that this end may not be depressed at all by the act, the net result will be a torque upon the primary abutment which will tend to pry the bridge cantilever off the tooth identically as the first illustration.

What will restrain the bridge from being pried off the primary abutment?

RESISTANCE FORMS

If we analyze the resistance units of a simple proximocclusal primary abutment to torque from the above cause we have: (1) The bond between the proximal flange and the tooth will resist the displacement of the bridge. Obviously, the more nearly the proximal flange is cut as a box with parallel and opposing walls the stronger the bond. Black's box preparation is nearer the ideal than the slice preparation. In the extreme slice preparation, there are no opposing walls for these are set at 180 degrees with respect to each other. (2) The isthmus resists the displacement of the cantilever. The isthmus, however, is tapered, is relatively small, and is effective to a degree only as great as the strength of the cement to shear. Since the displacing force is relatively powerful and, furthermore, enhanced by leverage, the strength of the cement to shear over such small bonded area is not significant. (3) The dovetail resists the displacement. The dovetail is probably the most important factor in maintaining retention. It can be easily proved, however, that the dovetail may be almost wholly ineffectual for the purpose. Its efficacy is determined by the degree of taper or "draft."

It can be stated in substance that there is a critical pitch for the dovetail cavity walls which must not be exceeded or the dovetail loses all mechanical resistance to displacement. The critical pitch is further influenced by the point of fulcrumage. Fulcrumage may occur at the dovetail, the extension of the inlay to include all of the sulcus, the gingival margin of the opposite inlay flange (MOD), or at the intersection of the neutral axis of the pontic with the neutral axis of the approximating inlay flange. In each successive case the pitch of the dovetail walls becomes more critical until in the final case the critical pitch is absolute perpendicularity with respect to the long axis of the bridge pontic.

MECHANICS AND BIOLOGY

Any appliance which firmly unites two teeth changes the character of the tooth movements in their sockets. This is true because each tooth is slightly medial with respect to every tooth posterior to it. Uniting two or more teeth firmly together greatly improves the foundational capacity of the investing tissues because the tooth movement of each individual tooth is changed from a simple rotation, as on a hinge axis, to one where bodily movement of the roots must occur. Thus to horizontal thrust one of the teeth must go down while the other comes up, and the axis of rotation occurs in the bone between them. Any appliance which retains the simple hinge axis of an abutment tooth fails to make the most of the foundational capacity of the investing tissues. This is, therefore, true of the cantilever bridge and all clasp-type partial dentures. Precision attachment type bridgework is next to fixed bridgework the most desirable construction for, by its rigid abutment coupling, it takes advantage of the greatest support which the foundational tissues are capable of.

TEMPERATURE AND METAL PROSTHESES

When food is eaten wide fluctuations of temperature are applied to the teeth. People drink ice water with freshly broiled steak. Metals conduct temperatures much more readily than mineral substances. Fillings which are retained entirely within the crown of the tooth, as occlusal and buccal fillings, will tend to shrink faster to the cold temperature than the tooth. This accounts for the rather frequent loosening of Class I and Class V inlays.

Two-surface inlays do not come out because the proximocclusal type of inlay makes use of an inside as well as outside fit between the inlay and the tooth. Any tendency for the inlay to shrink tends to compress the tooth between the dovetail and the flange. Since this is an elastic deformation, the inlay and tooth return to normal form just as soon as mouth temperature is restored.

A metallic restoration which is retained purely by frictional or bonded contact with the external surface of the tooth, as the gold crown, presents no problem to retention when it is cooled. When heated, however, it is conceivable that it will expand away from the tooth. This is especially true if it is supporting much metal as when it is a bridge abutment. If the heating of the crown is gradual, heat transfer through the crown probably expands the tooth enough to maintain positive retention.

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ACRYLIC IN JACKET CROWNS AND BRIDGE PONTICS

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PLASTIC products have been used in dentistry in a wide variety of ways. These have had many successful applications. One of them has been as a denture base material. More recently, the acrylic resin has been adapted for use as a material for jacket crowns and for bridge pontics.

After doing porcelain jacket crown work for twenty-five years, I find it tedious and painstaking. The control of shrinkage has always been a problem. The production of minutely detailed anatomy which is required in nearly every case is another. Spheroiding of the porcelain in the final fusing made it difficult to retain detail in labial anatomy. Spheroiding also causes a tendency toward rounding of the peripheral margins which would leave a discrepancy at the gingival margin. The material is friable and subject to fracture from impact.

The porcelain pontics furnished by the manufacturers have numerous shortcomings, such as improper anatomic form, difficulty in blending of shades for individual cases, and from the biologic standpoint. Cases with malaligned teeth are difficult to handle to produce desired esthetics when porcelain pontics are used.

The facts that prosthetic men have accepted acrylic as a denture base material, that the manufacturers were steadily improving the material, and that an acrylic pigmented for producing tooth shades was available influenced me to become interested in doing some research on its physical properties, with a view of determining its possibilities in crown and bridge prosthesis. After testing several manufacturers' products in the laboratory, I selected a few experimental practical cases. Needless to say, I had failures, not sufficient, however, to deter me from going ahead with its use. Some of the failures could be attributed to the materials which were available at that time, and which have been improved. I am confident the improvement in the materials will continue.

Most failures of acrylics in crown and bridge prosthesis may be attributed to the dentists themselves, who lack an adequate knowledge of the material and its limitations. Indiscreet salesmen will tell you how little time and effort is required for the preparation, the wax pattern, the investment and flasking, the packing and curing of the crown. They will say that you will then have a beautiful restoration. I can assure you it is not that simple.

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TECHNIQUE

I shall therefore attempt to outline the jacket crown procedure which has been developed over the years. Please remember that care and precision must be kept in mind.

For the preparation of the tooth, most patients prefer anesthesia. The needle is inserted beyond the apical end of the root and under the periosteum. The injection should be made slowly to avoid traumatizing the tissue. While waiting for anesthesia, the shade is selected and the anatomy of the tooth is studied carefully to note the developmental grooves and minute markings.

During the preparation of the tooth, the nurse or assistant keeps a constant but fine stream of warm water (approximately 100° F.) on the tooth to facilitate rapid cutting and to avoid shock to the tooth.

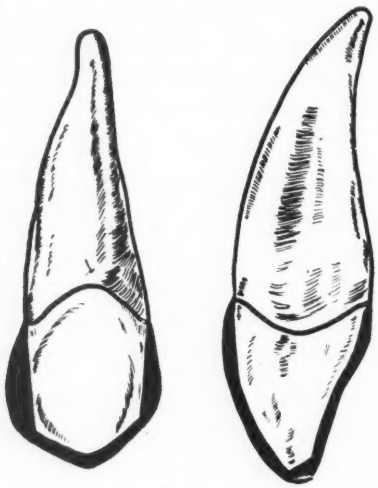

Fig. 1.

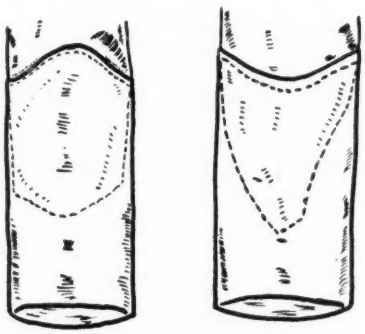

Fig. 2.

Fig. 1.—Enamel is removed from the tooth.

Fig. 2.—The copper band adapted to the tooth.

Diamond wheels, ¾ in. disks, and points are used for making the preparation on the tooth. Approximately 2 mm. are removed from the incisal edge of the tooth. The proximal surfaces are denuded with a ¾ in. diamond disk. A slight taper is made to the gingival margin. The lingual enamel is reduced by a round or barrel point. The labial enamel is reduced by a round-edge wheel. The slight ledge in the proximal enamel is removed to a bevel with a No. 1 Morris scaler. The lingual and labial surfaces are beveled beneath the gum margin with a pointed tapered point rotated counterclockwise on the left side of the labial surface and on the right side of the lingual surface, and rotated clockwise on the right side of the labial and on the left side of the lingual surface, from the center of the surface to the proximal surface (Fig. 1). A copper band is festooned, and the bur removed with a rattail file. The band must be annealed, and it must fit tightly to conform to the circumference of the tooth (Fig. 2). The proximal shoulder is then established by a disk. The labial and lingual

shoulders are established with a square-end tapered point, just short of the gum margin, and are carried cervically to 1 mm. beneath the gingival margin. The suggestions given above are observed for the direction of rotation of the point while giving the right-angle shoulder its final finishing (Fig. 3). This is accomplished with a square-end carborundum point for a final smooth finish (Fig. 4).

Fig. 3.

Fig. 4.

Fig. 3.—A square-end carborundum point is used to finish the shoulder.
Fig. 4.—The shoulder of the preparation.

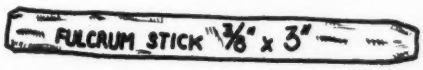

Fig. 5.

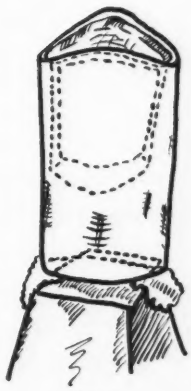

Fig. 6.

Fig. 5.—The fulcrum stick and the compound-filled copper band.
Fig. 6.—The impression.

The band is now filled with red modeling compound, and the impression is made with the aid of a fulcrum stick (Fig. 5). The stick is held firmly until the impression is chilled and removed (Fig. 6). A small bridge tray is filled with Aluwax for making an impression which will include the adjacent teeth. The Aluwax impression is made and removed from the mouth. A small amount

of wax is added just inside the impression of the prepared tooth. The Aluwax impression is then reinserted to obtain a more accurate impression.

A temporary crown is constructed from sheet baseplate gutta-percha. A piece of gutta-percha, 3/8 × 3/4 in., is heated and rolled into a cylinder. The cylinder is forced on to the prepared tooth to obtain an impression of it. It is removed and chilled in ice water. With a Bard Parker lance, the gutta-percha is carved to the exact periphery of the shoulder. The anatomy of the temporary crown is carved, and the crown is cemented into position. The excess cement is washed away immediately. *Do not dry the tooth before cementing the temporary crown.* The crown may be smoothed by chloroform on a cotton pellet.

Fig. 7.

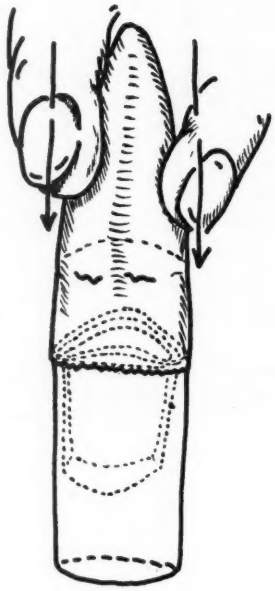

Fig. 8.

Fig. 7.—The amalgam die partly formed in the impression.

Fig. 8.—Forming the root portion of the amalgam die.

DIE AND CAST

One-quarter teaspoon of alloy is placed in a mortar, and sufficient mercury is added to amalgamate with it. The mixture is triturated until the mercury is thoroughly incorporated in the alloy. It is then mulled in the palm of the hand for final amalgamation. All free mercury is expressed with thumb pressure. An amount the size of a small pea is placed in the band impression. With a finger over the open end of the band, the impression is tapped firmly on the bench, and more amalgam is added and tapped into place until the die is packed 1/4 in. above the end of the band (Fig. 7). The remainder of the alloy is formed into a cylinder which is placed on the alloy already in the impression. The root form is built up by stroking the cylinder toward the impression (Fig. 8). Equal pressure between the thumb and finger is used to stroke the cylinder of

amalgam to the same taper from its end to the periphery of the band. The die should set at least four hours before the compound in the band is warmed and removed (Fig. 9). The die is trued with a garnet disk, tapered to within 3 or 4 mm. from the shoulder (Fig. 10), and flattened on the lingual side to serve as a guide to its proper seating in the cast (Fig. 11). The die is assembled in the Aluwax impression, sealed at the periphery, and the impression is poured in stone. For a single crown, it is not necessary to articulate the cast, except for posterior teeth or in cases with extreme irregularities. When the cast is set, the die is removed and 3 mm. are cut from the cast below the shoulder on the die (Fig. 12).

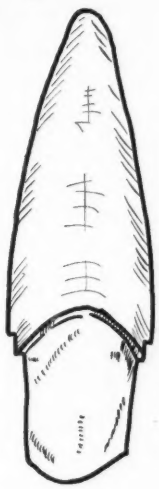

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 9.—The die.
Fig. 10.—The root portion of the die is trued and tapered.
Fig. 11.—The lingual side of the root portion of the die is flattened.

A sheet of 0.0005 tin foil is cut into strips $\frac{3}{8} \times \frac{3}{4}$ in. One corner of a strip of this tin foil is cut off at a 45-degree angle (Fig. 13). The tin-foil strip is then wrapped on the die with an overlapping, instead of tinner's, joint. It is carefully burnished to the shoulder of the die. A teaspoon three-fourths filled with nonpigmented wax is heated. The crown portion of the die is quickly dipped into the molten wax to form a film over the foiled die beyond the shoulder. The wax and foil are cut, allowing 1 mm. to extend past the shoulder. The die is returned to the cast, and the waxing is completed. The detailed anatomy is carved, the contact areas are added, and the wax crown is removed from the die.

FLASKING AND PACKING

The bottom half of the flask is filled with stone and, with a small camel's hair brush, the inside of the crown is filled with stone. The crown is invested in the flask with the labial surface exposed. When the stone is set, soap film is used as a separating medium, and the top half of the flask is poured. When this is set, the flask is separated and the wax is completely washed out with boiling water. A blast of air is used to remove the water. Plascote is applied

while the flask is hot, and allowed to cool to room temperature. Two glass mixing jars are used, one for the dentine color and one for the enamel color acrylic. Just sufficient acrylic monomer is added to the dentine acrylic to saturate it. It is stirred with a spatula, and the jar is closed. Acrylic monomer is then added to the enamel shade acrylic in an amount to make the same consistency as that of the dentine acrylic, then one drop more is added. The acrylic for the enamel shade should be a little more fluid than that for the dentine shade. The

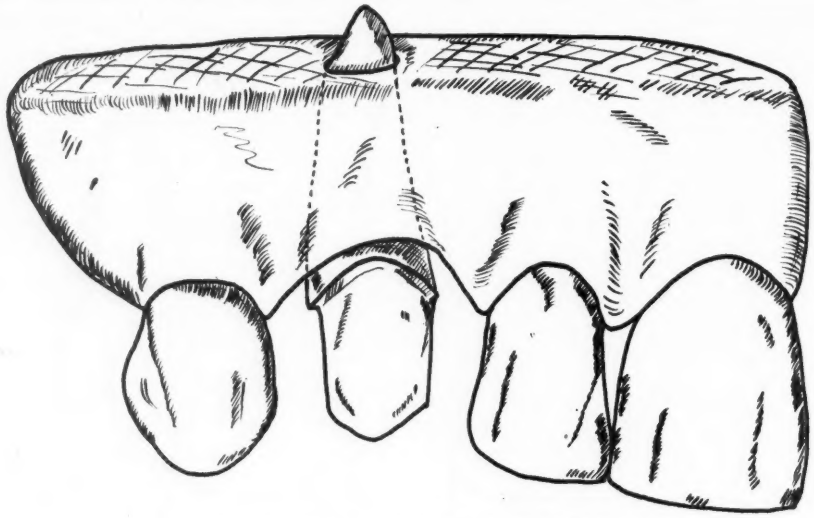

Fig. 12.—The cast with the die in position.

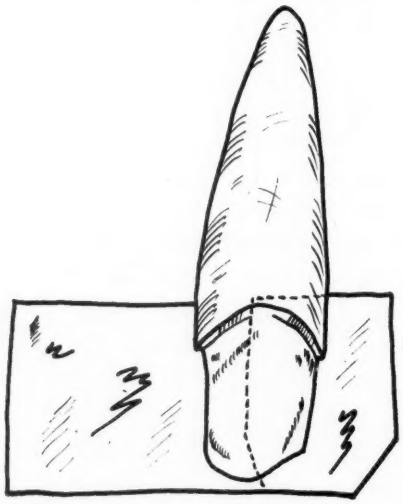

Fig. 13.—Tin foil is wrapped around the die.

material is spatulated frequently until the acrylic passes the tacky stage, and webs appear in the mix. A small amount of dentine-colored acrylic is placed at the incisal end of the mold, and pressed firmly toward the cervical end. This is repeated so the material on the lingual side is well condensed. Excess is

added over the labial surface. The acrylic is then covered with wet Cellophane, and the flask is closed in a press. The flask is opened, the Cellophane is moistened and removed. The excess acrylic is removed from the periphery with a spatula. The material at the incisal surface and proximal surface is pushed toward the cervical side. Enamel-shade acrylic is placed in the mold and covered with wet Cellophane. The flask is replaced in the press with a light pressure. The flask should be open to 1 to 2 mm. The flask and press are placed in a water bath at room temperature. Thirty minutes are allowed to bring the water-bath temperature to 165° F. During polymerization, the material becomes quite plastic at somewhere between 160 and 170° F. The flask is closed completely at this temperature. The excess material in the mold is compressed to obtain maximum density. The thermostat on the water bath is set at 190° F., and the time clock is set for four hours. The flask is bench cooled, and the crown is deflasked. The tin foil is readily removed with an excavator. The crown is placed on the die, and the apron removed with a fissure bur. The crown is then placed in water until it is seated.

The crown is adjusted in the mouth for contact and occlusion. The labial surface should not be polished, except at the cervical and proximal edges. The lingual surface is polished. Pumice and tin oxide are used as abrasives for polishing the crown. The crown is cemented with oxyphosphate of zinc cement.

ACRYLIC IN BRIDGE PONTICS

The acrylic resins have marked advantages over porcelain as bridge pontics. This is especially true in cases where there is a small amount of space between the edentulous areas and the opposing teeth, and in cases with irregular ridges.

The casts are mounted on an articulator; modeling compound is placed in the edentulous area. To provide space for gold occlusal surface, 1 to 1.5 mm. of the compound is carved out. A sheet of 0.001 tin foil is burnished over the occlusal area, and separating medium, such as Kerr's lubricant, is applied to the tin foil. It is then covered with 28-gauge matrix wax. Hard inlay wax is then built on to the matrix wax, and carved to the desired occlusal anatomy. A sprue is placed in its proper relation for casting, and the wax occlusal pattern is removed from the cast and the compound core. Then 18-gauge wax wire is attached to the cervical side of the occlusal pattern. Two loops to each pontic are usually attached from the buccal to the lingual surfaces, and not closer than 2 to 3 mm. to the ridge area. This is to provide stability in the attachment of the acrylic to the occlusal surface. The occlusal pattern is now invested and cast.

After the bridge is soldered, the gold occlusal pontic is finished and polished. It is then returned to the cast, and the pontic waxing is completed. Clear or unpigmented inlay wax is carved into the anatomic form and ridge relation. It is then flasked for processing in the manner outlined for jacket crowns. The pontic should be of a semisaddle type, highly polished and with all biologic principles observed.

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RÉSUMÉ OF THE EXPANSION REQUIRED TO COMPENSATE FOR CASTING GOLD SHRINKAGE

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WHEN Taggart[1] presented his dental casting technique in 1907, the casting shrinkage of gold alloys was not known; little consideration was given to it until 1910 when Van Horn[2] and Price[3] (in 1911) recognized it as an important factor in the fit of the casting. Price determined the shrinkage of pure gold to be 2.2 per cent, which is quite close to the thermal contraction of gold from its melting point to room temperature, and not what we would call its actual casting shrinkage. Van Horn's paper was the first to point out a shrinkage compensation technique. He expanded the wax pattern by mixing the investment with warm water (about 115°F.), and then he let it set in a water bath at 110°F. While he did not attempt to determine the amount of expansion required, he made a great contribution to the accuracy of inlay casting.

In 1923 Shell[4] found the shrinkage of pure gold to be 1.71 per cent when cast in a hot mold and 1.99 per cent when cast in a cold mold. Coleman,[5] working at the Bureau of Standards, determined the shrinkage of several gold alloys and pure gold. He made castings 3.25 inches long and 0.12 inch in diameter and found the casting shrinkage to be 1.25 per cent.

Following this important work many techniques were introduced which, to a certain extent, compensated for the shrinkage of the gold alloy. With some of these techniques, expansion more than enough to compensate for the gold shrinkage could be obtained, and much consideration has been given during the last twenty years to these questions: (1) What is the actual shrinkage of gold alloys? (2) Is it the same for all gold alloys? (3) Is more expansion required for some types of inlays than others? (4) Does setting expansion compensate for any of the shrinkage? (5) What is the amount of expansion required of an investment to entirely compensate for the gold shrinkage?

We have attempted at various times to find the answers to these questions and occasionally have been confused by the data obtained.

When we learned through Coleman's work that the casting shrinkage of gold alloys was 1.25 per cent, an investment having 1.25 to 1.35 per cent thermal expansion was found to entirely compensate for the shrinkage of the gold alloys for making mesio-occluso-distal and full-crown castings. These investments, however, in addition to the thermal expansion had a setting expansion of from

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0.30 to 0.35 per cent, but this was considered to have no effect upon the fit of the casting. Therefore, it was thought that if we could make an investment with zero setting expansion and control the thermal expansion, more accuracy could be obtained.

In 1932 we made investments having zero setting expansion and thermal expansions varying from 1.25 to 1.40 per cent. These investments were used by both Crawford[6] and Van Horn[7] in experimental work, and neither was able to make an MOD or a full crown with any of these investments that accurately fit a steel die. While doing this work we made investments varying in thermal expansion from 0.8 to 2.0 per cent, and from zero to 0.4 per cent setting expansion.

Crawford, then at Columbia University working with a group of experienced operators, made several hundred practical castings of all types. Careful records were kept of the type of casting, the gold alloy, the setting and thermal expansions of the investment, and the conclusion reached through this investigation was that best results were obtained by using investment having two thermal expansion levels, depending upon the shape and retention of the area of preparation.

Crawford established the thermal expansion of 1.0 to 1.1 per cent for castings with small retention and short converging cavity walls (mesiocclusal, distocclusal, and three-quarter crown anterior); and 1.3 to 1.4 per cent for the group of castings which had much retention and with long parallel walls (MOD, three-quarter crown posterior, full crowns, and one-surface inlays). In addition to the above-mentioned thermal expansion, each of these investments had a setting expansion of approximately 0.3 per cent, and an unknown hygroscopic expansion.

In 1932 Scheu[8] discovered that certain investments would have a setting expansion of as much as 2 per cent if they were allowed to set under water. He called this expansion under water hygroscopic expansion, and introduced a very accurate technique employing the use of a hygroscopic investment. He found that a hygroscopic expansion of at least 1.6 per cent was required to compensate for the shrinkage of dark 22-carat gold alloy, and that more was required for light-colored 22-carat gold alloy and pure gold, while the hard gold alloys required less expansion.

Since several investigators had obtained casting shrinkage results that were considerably higher than the 1.25 per cent reported by Coleman,[5] Hollenback,[9] working with Skinner, very accurately determined the casting shrinkage of pure gold and gold alloys. He used a specimen that more closely approximated the size of an inlay than the 3.25 inch specimen cast by Coleman. His rod was 1 inch long and 0.14 inch in diameter. Hollenback's results show the casting shrinkage for pure gold to be 1.67 $\pm$0.02, and for 22-carat dark gold alloy to be 1.50 $\pm$0.01. The lowest casting shrinkage reported by Hollenback was 1.30 per cent, which was for an alloy containing an atomic per cent of 43.5 gold and 15.0 platinum.

When it appeared quite evident through Hollenback's work that the casting shrinkage varies for different alloys, we then started an investigation to determine the total combined expansion required in order to completely compensate

for the casting shrinkage of a number of gold alloys. This work was started in 1945 and part of it was reported by Watts in 1946.[10] In this present work we have made a total of 491 castings. Most of these were for the Bureau of Standards MOD and full-crown steels dies, but we also used mesiocclusal and three-quarter anterior porcelain tooth dies. We used forty different investments, including four commercial investments. Sixty-one different gold alloys and pure gold were obtained from eleven manufacturers, and for making the wax patterns two inlay waxes were used. The complete physical properties of each constituent involved in the test were determined, using the standard established procedures.

The expansion properties of the investment materials which we determined are: (1) setting, (2) hygroscopic, and (3) thermal. These properties were obtained for each water-investment ratio that was used in the tests. The shrinkage curve of each inlay wax was carefully established. From the manufacturers of the gold alloys we obtained the melting points as well as available physical properties; however, we do not have the exact composition of all the alloys tested.

After making one or more MOD castings for the Bureau of Standards steel die with each investment, we selected an experimental investment which had high setting expansion and high thermal expansion for making a series of castings, using the various types of gold alloys.

Since this investment had a high setting expansion, we were interested in determining what influence the inlay ring had upon the setting expansion, and whether or not a single layer of asbestos was sufficient to allow the setting expansion to go to completion. We therefore ran setting expansion tests of the investment in 3-inch diameter and 2.5-inch high rings. Small brass markers having reference lines were placed in the investment 2.5 inches apart. This made it possible to measure the setting expansion of the investment confined in the ring. The results of this test are shown in Table I. All mixes in this test were made using a 30/100 water-investment ratio.

When no liner is used we find that the setting expansion is almost entirely restricted. Only 0.03 per cent expansion is found. One layer of wrapping paper 0.005 inch thick allowed only 0.1 per cent, while one layer of wet asbestos 0.028 inch thick permitted the complete setting expansion and hygroscopic expansion of 1.07 per cent. Two layers of asbestos did not give any more expansion, showing that the one layer is sufficient to allow for at least 1.0 per cent of hygroscopic expansion.

TABLE I.

(INVESTMENT I.N. 158. W/I = 30/100)

TEST NO.	SETTING EXPANSION (%)	REMARKS
1	0.03	No liner
2	0.10	One layer wrapping paper
3	1.07*	One layer wet asbestos

*When the ring is lined with wet asbestos the expansion obtained includes hygroscopic expansion.

TABLE II.

TOTAL EXPANSIONS FOR VARYING CONSISTENCIES
(INVESTMENT I.N. 158)

W/I (ML./GM.)	SETTING EXPAN. ONE HOUR (%)	HYGROSCOPIC EXPANSION* (%)	THERMAL EXPAN. AT 1350° F. (%)	TOTAL (%)
32/100	0.87	0.17	1.05	2.09
30/100	0.91	0.17	1.08	2.16
28/100	1.00	0.14	1.11	2.25
26/100	1.06	0.15	1.12	2.33

*Hygroscopic expansion for one layer of asbestos saturated with water. The total expansion varies from 2.09 per cent to 2.33 per cent as the consistency is thickened from 32/100 to 26/100.

Table II shows the setting, hygroscopic, and thermal expansions of this investment. The water-investment ratio was varied from 26/100 to 32/100, thus giving us a range of total expansion from 2.09 to 2.33 per cent.

The Bureau of Standards MOD steel die was selected for a series of castings and over two hundred were made, using the sixty-one different gold alloys. The MOD steel die was chosen because it has been accepted as a standard, and because it makes possible quite rapid production of accurate wax patterns that can be easily duplicated. Also a trace of shrinkage or overexpansion is readily detected in the finished casting. The primary purpose in making these castings was to determine the amount of investment expansion required to entirely compensate for the casting shrinkage of a number of selected gold alloys. We held all other variable factors as nearly constant as possible.

Since the wax pattern is one of the most difficult to control variables, I think it is well to give a short description of the technique employed to make the pattern and invest it. Ransom & Randolph Standard Blue Wax was heated to approximately 180°F. and poured into the die. The cap was fitted on the die, and the wax was held under finger pressure until it solidified. The outer ring was then removed, and the margins were carefully trimmed. The sprue (0.093 inch diameter) was attached to the center of occlusal surface, and the steel die, with the wax pattern in place, was set in a water bath at 95°F. for five minutes. It was removed from the water, wiped dry, and the pattern was placed on a crucible former, allowing approximately a one-quarter inch long sprue. The pattern was painted with an aerosol solution and invested within ten minutes after removal from the die. The room temperature was held to 75° F. ±3° F. The investment, distilled water, mixing equipment, and inlay ring were all kept at the same room temperature. While our tests showed that one layer of asbestos was sufficient to allow the setting expansion to go to completion and two layers did not alter the results, as a safety measure we used two layers of asbestos.

The asbestos-lined ring was submerged in a beaker of water and shaken three to four times to remove the excess water. The investment was mechanically spatulated two hundred turns of the blade, and the pattern was painted with a small sable hair brush. The inlay ring was placed on a glass slab, filled with

investment, and the painted pattern was carefully embedded in the investment. Ten minutes (prior to the initial setting time) after the start of the investment mix, the filled ring was placed in a constant temperature oven held at 135°F. After one hour the sprue pin was removed, and the ring was transferred to an electric furnace which was at room temperature, and then heated to 1,350°F. The total burn-out time was one and one-half hours. The reason for warming the invested ring during the period in which the setting expansion took place was to soften the wax so that the investment core within the MOD pattern could freely expand. Tests in which the investment core was measured by a comparator microscope demonstrated the importance of this treatment.

TABLE III

TEST NO.	GOLD TYPE	W/I	TOTAL EXPANSION	FIT
90	Soft	26/100	2.33	Loose
93	Soft	30/100	2.16	Easy
106	Soft, 22 kt.	28/100	2.25	Easy
111	Soft, 22 kt.	28/100	2.25	Easy
102	Soft	28/100	2.25	Snug
105	Soft	28/100	2.25	1/64″
121	Soft	28/100	2.25	0.007″
78	Med. Hard	26/100	2.33	1/64″
99	Med. Hard	28/100	2.25	Easy
107	Med. Hard	28/100	2.25	Tight
108	Med. Hard	28/100	2.25	Easy
112	Med. Hard	28/100	2.25	Easy
115	Med. Hard	28/100	2.25	Easy
94	Hard	30/100	2.16	Easy
89	Hard	28/100	2.25	Snug
97	Hard	30/100	2.16	Snug
96	Extra Hard	30/100	2.16	Snug
103	Hard	28/100	2.25	Snug
101	Hard	28/100	2.25	Snug
104	Hard	28/100	2.25	Easy
109	Hard	28/100	2.25	Easy
110	Hard	28/100	2.25	Easy
123	Hard	28/100	2.25	Snug

In Table III are shown the results of twenty-three of the test castings, using twenty-three different gold alloys, including soft, medium hard, and hard gold alloys. We have recorded the type of gold, water-investment ratio, total expansion, and a description of the casting fit. The fit of the casting is described as tight, snug, easy, or loose, depending upon the ease with which it could be seated. A tight fit is a casting that is a little too small. It can be seated with strong finger pressure, but when it is removed, it will show a bright mark on the inside near the occlusal surface on the mesial and distal walls where the steel die has burnished the casting. A snug fit is a casting that goes to place with moderate finger pressure. An easy fit is a casting that goes to place with light pressure, and a loose fit is a casting that will almost drop to place.

We have tried to summarize the typical results with these twenty-three castings. A careful study of Table III indicates:

1. That there is a definite difference in the shrinkage of various gold alloys that are classified as soft golds.

2. That these soft golds may be classified into two groups:

A. Soft gold alloys which have the highest casting shrinkage. (Examples are Tests 102, 105, and 121.)

B. Soft gold alloys having lower shrinkage, almost approaching that of the medium hard inlay casting gold alloys. The 22-kt. dark gold alloys belong to this group. (Examples are Tests 90, 93, 106, and 111.)

3. That the difference in the shrinkage of the Group B soft gold alloys, the medium hard gold alloys, and the hard gold alloys is not sufficient for us to definitely detect it from the standpoint of fit of the casting. There was an indication that the shrinkage of the hard gold alloys is less; however, we doubt if it is more than the experimental error of the technique.

The wax patterns were adapted to the MOD steel die at 95°F., removed from the die, and invested at a room temperature of 75°F. The inlay wax used in these tests has a shrinkage of 0.58 per cent when cooled from 95 to 75°F.

If we subtract this wax shrinkage from the total combined expansion of the investment, we find that from 1.67 to 1.75 per cent investment expansion is required to compensate for the shrinkage of the Group A soft gold alloys, and from 1.55 to 1.67 per cent for the Group B soft gold, medium hard, and hard gold alloys.

MOD castings of pure gold would indicate that about the same expansion is required as for the light-colored 22-carat gold alloys (1.75 per cent).

SUMMARY

1. We feel that we have proof that setting expansion is effective in compensating for the gold alloy shrinkage. We realize that the shape of the wax pattern and its temperature during the setting stage of the investment determines the amount of setting expansion that is utilized.

2. Hygroscopic expansion, when taking place at 98 to 100°F., will compensate for the casting shrinkage; with its use the shape of the wax pattern has no influence on the amount of expansion required. Taking into consideration the influence of all the variables, we have obtained most consistent results when using the hygroscopic technique.

3. With the exception of pure gold, and some of the soft inlay gold alloys, we believe it is not necessary to vary the amount of expansion to compensate for the casting shrinkage of the different inlay gold alloys on the dental market.

4. We have not been able to fit a dental inlay casting to a steel die when the combined compensating expansion was 1.25 per cent.

5. It is our opinion that a combined compensating expansion of at least 1.50 per cent is necessary to compensate for the casting shrinkage of the available inlay gold alloys.

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THE CONGENITAL CLEFT OF THE PALATE

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THE ETIOLOGY of the cleft palate, like that of the cleft lip, is unknown. In about 25 per cent of the cases, heredity appears to be a factor. The remaining 75 per cent are of obscure etiology. It is interesting to note that several workers have been able to obtain entire litters of rats and cats with clefts in the palates by variations in diet.[1]

PRELIMINARY TREATMENT

Practically all cases of cleft palate will present varying degrees of feeding problems, due to the fact that the power of sucking is lost. A strong healthy baby will usually do very well with an ordinary nipple. Weak babies usually require special methods. The Breck feeder or the Pliofilm bottles are of considerable help.

SURGICAL TREATMENT

The surgical treatment must be aimed at securing nasopharyngeal closure with a soft, mobile functioning palate. This is accomplished by the action of the superior constrictor muscle of the pharynx narrowing the opening and pulling the posterior wall forward to meet the rising palate. The palate is elevated largely by the levator veli palatini. Actually this is a true sphincter action.

With this in mind, one can now consider the other aspects of the palate problem. These are the development of adequate speech and avoidance of disturbances in growth patterns of the maxilla. It is our opinion that the time of surgery and the type of palate are of first importance.

TIME OF SURGERY

One of the determining factors is operative mortality. Veau,[2] in 1933, reported a 5.2 per cent mortality under the age of 1 year. After 2 years of age the rate dropped to zero. Certainly with modern anesthesia this figure would be reduced, but nevertheless one can see that the older the child the safer the operation.

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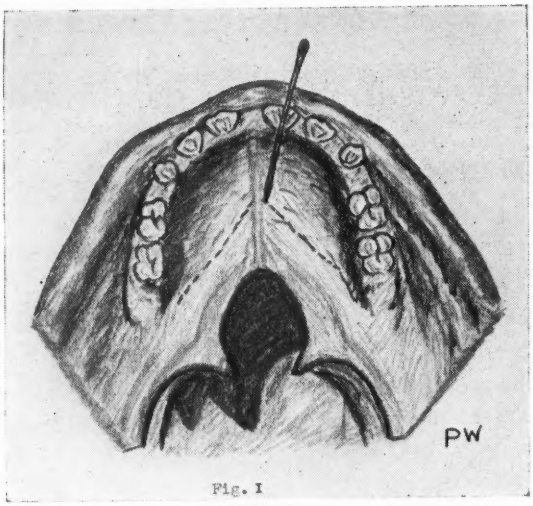

Fig. 1.

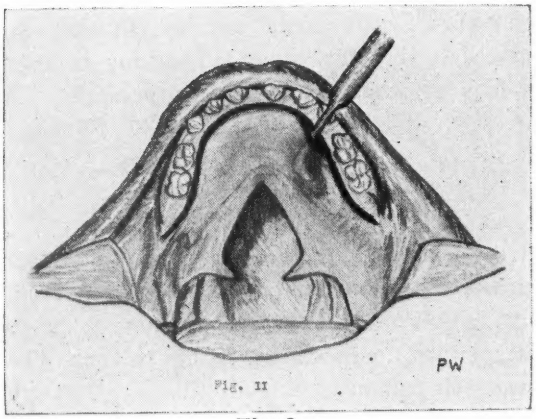

Fig. 2.

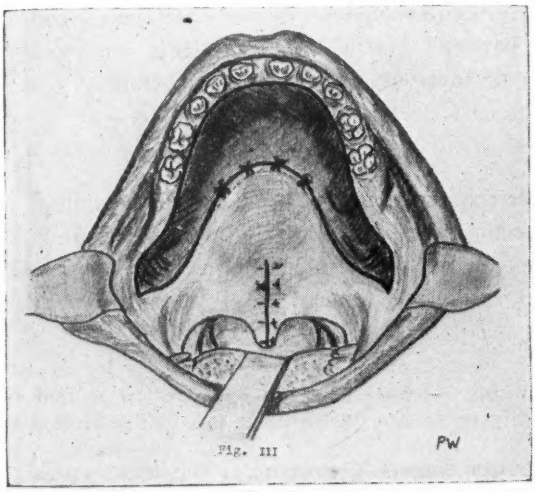

Fig. 3.

A second factor in determining time for operation is the development of speech. Smith, quoted by Seth and Guthrie,[3] states that the average child of 1 year of age has a vocabulary of three words, while at 3 years, the vocabulary is approximately nine hundred. This shows that speech patterns are developed very early in the period from the first to the third year. In view of this, many speech therapists feel that palate repair should be carried out before speech habits are developed, that is, between the first and second years.

A third factor in determining the time of surgery is the development of the maxilla. In early childhood the growth rate is rapid and any interference is liable to cause retardation. The scar tissue developed subsequent to the palate repair may work in this direction. This is particularly true of any type of repair which involves direct attack on growing bone or depends on compression for closure. It is our feeling that, in cases of cleft palate, there is an inherent growth defect and such operations, as those of Brophy and Warren Davis definitely accent it and should be abandoned.

It can be seen that there is argument for both the early and late repairs of the palate. It is our feeling that all these factors, in addiiton to the chronic otitis media and hearing loss subsequent to open palates, must be weighed carefully, and each case individualized on the basis of the type of palate present.

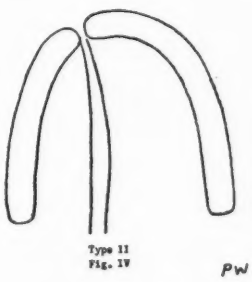

Fig. 4.

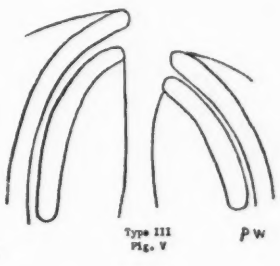

Fig. 5.

TYPE OF CLEFTS OF THE PALATE

The first and simplest type is that of the median cleft shown in Figs. 1, 2 and 3. This may involve varying distances of the hard palate and, because of the intact alveolar ridge, may be repaired early. There is very little, if any, disturbance in growth and no tendency of the maxilla to collapse. This cleft is usually associated with insufficient length,[4] and when repaired should be "pushed back." We use the method of Brown[5] shown in Figs. 2 and 3. This is a modification of the Dorrance "Push Back" operation.

The second type of cleft, illustrated in Fig. 4, has a fairly small defect in the alveolus. The premaxilla is in line with the arch. Usually closure of the lip has completely closed the alveolar cleft. In this case, early closure of the palate will not cause collapse of the maxilla. The growth pattern does not seem greatly disturbed.

Type III presents a different problem. The defect in the alveolus is wide and the premaxilla protrudes. Closure of the lip results in collapse of the maxilla as shown in Figs. 5 and 6. The further scarring incident to palate repair increases the collapse and further disturbs the pattern of growth. There will be severe malocclusion and deformity of the maxilla with consequent poor cosmetic result because of failure of development of the central third of the face. In this type, repair should be deferred until such time as orthodontic retaining devices may be employed.

Type IV (Fig. 7) illustrates a condition similar to Type II, but in a double cleft. Closure of the lip closes the alveolar arch, and little disturbance takes place consequent to palate repair.

Type V (Fig. 8) is comparable to Type III, but in a double cleft. Closure of the lip closes the lateral plates of the maxilla behind the premaxilla, causing considerable deformity (Fig. 9). Early repair increases the deformity and we prefer to wait until orthodontic appliances can be employed.

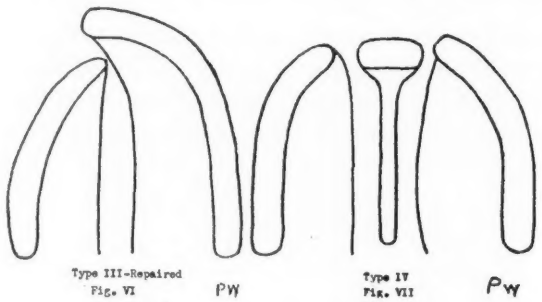

Fig. 6.

Fig. 7.

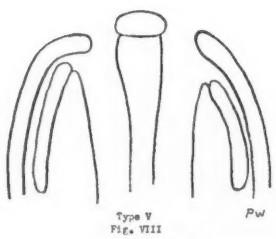

Fig. 8.

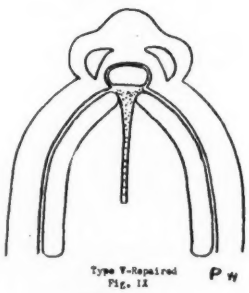

Fig. 9.

OPERATION AND ANESTHESIA

The operation is a modification of Von Langenbeck's procedure. The edges of the cleft are split into nasal and buccal leaves. Lateral relaxing incisions are made along the alveolus and carried well back along the ramus of the mandible. The entire mucoperiosteum is elevated, preserving the palatine arteries. The hamular process is exposed and fractured, allowing the tensor veli palatini muscle to move back into the position of a levator. The constrictor portion of the palate is freed by blunt dissection in the pterygoid space. The palate is now

completely free, except for the palatine arteries. If the two leaves do not fall together easily and without tension, the arteries are freed in the canal, thus gaining length. Closure is then carried out in layers, with silk to the nasal and oral mucous membrane, and fine chronic catgut to the muscle.

In cases of a complete cleft, with a short palate, we employ a modification of the V-Y advancement of Wardill.[6] This gives length but often results in a small opening anteriorly, requiring secondary closure.

The postoperative care is minimal. Sutures are allowed to fall out. Penicillin is used for three to five days. Care must be taken to prevent the child from putting his fingers or other objects in his mouth until healing takes place. Soft diet is continued for about two weeks.

We have employed several methods of anesthesia, that is, endotracheal, nasal insufflation, and oral insufflation with ether and oxygen. Invariably, we have come back to the latter, because of the ease and lack of interference with the operator. The anesthetist wears a gown and gloves and is one of the team. He controls the anesthesia as well as the two-way suction. Even though the operation is a short one, we insist on a completely adequate airway. This is maintained by suction and careful positioning of the child's head in the operator's lap.

The immediate result of surgery is a high percentage of complete closures. The final results, however, are short of perfection by a great deal. Most cases require varying degrees of speech therapy. A fair number require orthodontia, and a few prosthodontia. Because of these factors we feel that the formation of cleft palate teams, consisting of the plastic surgeon, orthodontist, prosthodontist and speech therapist, should be established. A child psychologist also should be available.

CONCLUSIONS

1. Each cleft palate patient should be individualized in regard to treatment.
2. Cleft palate teams of surgeon, orthodontist, prosthodontist, and speech therapist are a necessity.

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CASE REPORT OF CONGENITAL ECTODERMAL DYSPLASIA AND REHABILITATION WITH DENTURE PROSTHESIS. II.

S. G. Applegate, D.D.S. and Lawrence Cotman, B.S.*

University of Detroit, School of Dentistry, Detroit, Mich.

THE VALUE of early recognition of congenital ectodermal dysplasia, along with its immediate medical and dental treatment, is well illustrated by the following case.

R. K., an 8-year-old boy, was seen at the University of Detroit, School of Dentistry, Nov. 10, 1950. Work on the patient was started immediately, since he was sensitive to the teasing to which he was being subjected by his classmates. He was aware of the good results accomplished for his brother who had the same condition. He was also acutely aware of the second looks given him by strangers due to his dental deficiency. This mental reaction prevented him from proper general development; therefore, dental prosthesis was deemed necessary.

PHYSICAL EXAMINATION

This 8-year-old lad gave a picture similar to that of his brother.[1] He measured 51½ inches as contrasted to 50 inches which is normal for a boy of that age. His weight was 40 pounds as compared to 51 pounds which is normal. The facial expression was like that of an infant with a tinge of "old mannish" features. His lips were prominent and protuberant. His hair was yellowish in color, sparse and coarse. His skin (Figs. 1 & 2) appeared to be smooth and excessively dry. In his mental outlook, as contrasted to that of his brother, he appeared quite interested, although he was fidgety at times while in the dental chair.

DEVELOPMENTAL AND PREVIOUS HISTORY DATA†

The blood pressure of the mother at the seventh month of pregnancy was 250. The child was delivered by forceps under forced labor, placed in an iron lung for twenty-four hours, and then in an incubator for two months. Starting at 6 months of age, ½ grain of thyroid was given him which had changed him, at the age of 6 years, into an active and alert youngster. When he was 2 years, 3 months old, he was given ¼ to ½ grains of thyroid on alternate days. This was found to be inadequate and he was therefore placed on a 1½ grain dosage of thyroid which is still being administered.

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*Student, University of Detroit, School of Dentistry.

†Data furnished by Glandular Clinic of Detroit Public Schools.

Radiographic examination of the patient at 1 year of age revealed that growth in bone centers was delayed, and that there were no tooth buds present in the mandible. At 2 years, 7 months, it was noted from radiographic dental examination that the upper central incisors had appeared.

Lateral tooth buds were present, but remaining tooth buds in the upper maxilla were absent as were all the tooth buds in the lower jaw. Fig. 3 shows radiographic pictures at 5 years, 7 months.

Fig. 1.

Fig. 2.

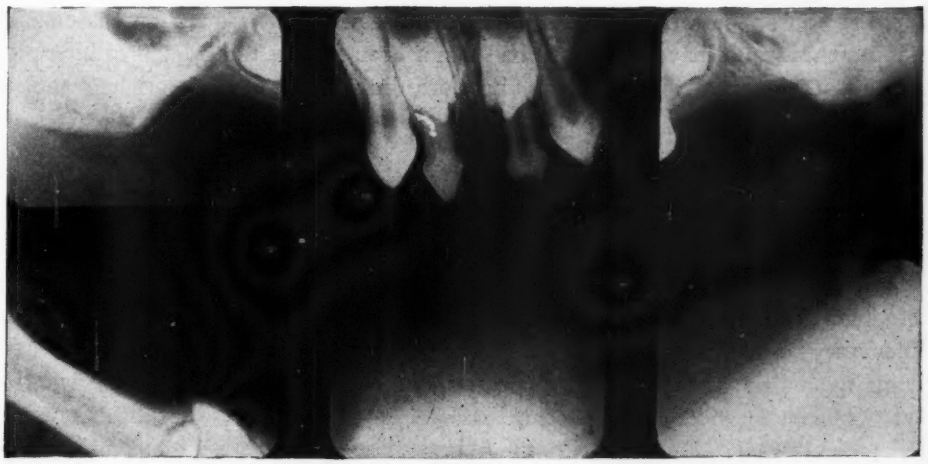

Fig. 3.

At 6 years, the child was presented to the Detroit Glandular Clinic with definite signs of pituitary and thyroid deficiency symptoms. His hair was strikingly fine in appearance and resembled that of his brother. He appeared quite active, alert, and obviously interested in what was going on. There was no abnormal emotional reaction.

At 6 years he had an I.Q. of 103.

The child had chicken pox in February, 1947 and developed pneumonia Aug. 20, 1947. The patient was discharged from the Glandular Clinic in 1947. He also has slight asthmatic condition.

The laboratory tests revealed the following results: Kahn, negative. Other blood tests run were normal.

ORAL EXAMINATION

In contrast to his brother,[1] the patient had but four erupted teeth. These were two permanent central incisors having the appearance of Hutchinson's teeth, and two cuspids which were conical in shape. The teeth in the upper arch were caries free, probably due to the fact that there was no occlusal or proximal contact; this facilitated their cleansing. The ridge of both maxilla and mandible were "knifelike." The upper vault was flat, but well developed.

Radiographic examination revealed that there were permanent tooth buds at the apex of the upper cuspids, while in the lower arch, in the bicuspid region, there were imbedded a deciduous cuspid which was fully formed but lying horizontally and a permanent bicuspid tooth bud lying next to the cuspid.

DENTAL TREATMENT

After careful study of study casts, radiograms, and clinical findings, it was decided to extract all permanent teeth and the tooth buds located at the apex of the cuspids, and also the deciduous cuspid and bicuspid in the left lower cuspid region of the mandible. A partial denture with full crowns on the cuspids as abutments would have been used had it not been for the tooth buds of bicuspids located at the apex of the cuspids. Therefore, in contrast to his brother, complete denture prosthesis was decided upon.

The upper teeth were extracted with nitrous oxide anesthesia. Care was taken in removing the upper teeth to prevent the removal of alveolar bone. Likewise, care was taken in removing the lower teeth in the bicuspid region to prevent the destruction of that ridge. A full denture was then constructed using the smallest twenty degree posterior plastic teeth. The second molars were omitted. The anterior teeth also were of plastic and were light in color. When they were placed in wax, the central and lateral incisors were separated, giving them the appearance natural to a child of his age. No trouble whatsoever was encountered in registering centric relation by a Gothic arch tracing. The patient was so pleased with the wax try-in that he was reluctant to give them back to the operator. The difference in facial appearance will be appreciated by observation of the Figs. 4 and 5.

PSYCHOLOGIC ASPECT

The psychologic effect of the dentures immediately on insertion was stupendous. At first the patient was shy and tried to keep his lips closed, but after his own private observation, he was not ashamed to smile and show them to others. His immediate remark was that "it was just like another Christmas."

He now is making new friends, is not shy or retarded due to his appearance, and is doing much better in school. Within a period of three months, his weight had increased 14 pounds. As Savara said,[1] "The reward for the enormous outlay of time and energy comes when the operator appreciates that his efforts have indeed made possible a new personality with greater possibilities of a longer, happier, and more effective life."

DISCUSSION

Let us now consider the probable effect these dentures will have on maxillary and mandibular growth in a child 8 years old. First, we recall that growth in the maxilla is sutural and by proliferation of connective tissue while that in the mandible develops as membranous bone, lateral and some distant to Meckel's cartilage. The main growth center is in hyaline cartilage in its condyle. The coronoid process and the condyle appear at the fifty-fifth day of uterine life. The hyaline cartilage in the mandible is covered by a thick layer of connective tissue. This layer allows the hyaline cartilage in the condyle of the mandible to increase in thickness by interstitial and appositional growth. Growth in width of the mandible is due to lateral apposition on the outer plate and resorption on the inner surface, while growth in height is due to growth at the alveolar border and also growth at the ramus.[2]

Fig. 4.

Fig. 5.

Scientists have noted that development of teeth and jaws in animals is not interdependent. The same results have been found in man where the jaws developed fairly normal size in cases of anodontia.[3] Growth of the alveolar process does not develop if teeth are absent, and also the alevolar process tends to disappear if teeth are lost.

According to Lewis,[2] "the greatest increase in intercanine width occurs between the ages of 6 to 8 and is greatest in the maxilla." Cohen also believes that rapid growth in arch development occurs between 6 and 8 years of age, (that is, from canine to canine and deciduous molar to deciduous molar).[2] This growth continues slowly until 12 years. He found that there is some lateral growth between the ages of 6 and 10 years in the first deciduous molar region. Definite growth appears in the canine region between the ages of 5½ and 8½ years. Cohen[4] found no nateral growth in the mandibular canine area after 9 years either in boys or girls. Recapitulating, the greatest lateral growth occurs in the canine during the eruption of the first permanent incisor (8½ years in maxilla and 8 years in mandible). Cohen found that there was little lateral growth in the arches in the inter first permanent molar and only slight growth in the inter premolar region.

From the foregoing remarks we can conclude that the greatest amount of growth that is going to take place in the maxilla or mandible has occurred by 8 years of age, and so the psychologic benefits to the patient wearing dentures offsets the possibility of the dentures retarding growth.

This is is all the more reason why this youngster should be watched to determine if there is any impingement or sore spots or bone stimulation developing as a result of wearing dentures. Should this be the case, they should be remade at once. At this point, it is impossible to say how often these dentures will have to be changed, or what effect they will have on the maxilla or mandible.

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The Readers' Round Table

Wellington, New Zealand

Editor, Journal of Prosthetic Dentistry,

I note with pleasure your exception to Leonard S. Fletcher's statement (**2**:235, 1952) that the lower anterior teeth " . . . must be set on the crest of the ridge."

You point out that with the teeth in this position the exact restoration of the patient's profile is impossible.

I would suggest that both Dr. Fletcher's somewhat broad statement and your own rebuttal (**2**:142, 1952) should be qualified by a time factor. Since the bony profile of the chin and alveolar bone is generally S-shaped it becomes probable that:

1. With a lower denture made before or immediately after extraction, setting the anterior teeth on the ridge crest will be almost correct.

2. After three months to one year of absorption, setting on the ridge will not restore the profile and, furthermore, will encroach upon the tongue space anteroposteriorly, with consequent discomfort to the patient.

3. After many years of ridge absorption, teeth set on the remains of the ridge crest might be in any relationship to the position of the original teeth, the relation depending upon whether the patient's chin is (a) normal, that is, upright, (b) receding, or (c) prominent.

It is with receding chins that the most disastrous results from "crest of the ridge" setting occur, as the tongue is forced back into the gullet and may become quite sore at the tip. If this condition is not remedied a proportion of these patients become psychoneurotic.

Yours faithfully,

C. L. Maloney, B.D.S.

News and Notes

ANNOUNCEMENTS

The twenty-fourth annual meeting of the American Denture Society will be held at the Sheraton Hotel, St. Louis, Mo., on Friday and Saturday, Sept. 5 and 6, 1952. Further information may be obtained from the secretary, Dr. Arthur L. Roberts, Aurora National Bank Bldg., Aurora, Ill.

The Twenty-eighth annual Greater New York Dental Meeting will be held on Dec. 8-11, 1952, at the Hotel Statler, New York, N. Y.

The American Academy of Implant Dentures was formed during the Chicago Midwinter Dental Meeting. Its purpose is the ethical promulgation of "Implant Dentures" through a cooperative effort by a mutual exchange of research advancements and attainments in this phase of dentistry.

The field contains three major participants: prosthetic, surgical, and technical.

The qualifications necessary for participation in this academy are as follows: Membership in good standing of the American Dental Association or a component society thereof; or if beyond the territorial limits of the United States, membership in good standing of a recognized dental society. The applicant for membership must have made successful advancements in this field.

For further information write: The American Academy of Implant Dentures, Office of the Secretary, Dr. Philip S. Loechler, 215 - 10th Street, S. E., Rochester, Minn.

The Houston Academy of the Dentistry has established the L. I. Kercheval Memorial Fund which will be used to help worthy senior students at the University of Texas Dental Branch and young dentists in their first year of practice. Many of Dr. Kercheval's friends throughout the country may wish to contribute to this fund. Checks may be made to the Houston Academy of Dentistry, L. I. Kercheval Memorial Fund, and mailed to 3217 Montrose Blvd., Suite 115, Houston, Texas.

The American Board of Prosthodontics will hold its next examination at the School of Dentistry, University of Indiana, 1121 West Michigan Street, Indianapolis 2, Ind., February 1-7, 1953. For further information write to Dr. Irving R. Hardy, Tufts College Dental School, Boston, Mass.

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